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Beyond smoking prevalence: Understanding smoking behaviour patterns in young adults and their associations with residential environment features

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Beyond smoking prevalence: Understanding smoking behaviour patterns in young adults and their associations with residential environment features

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Résumé

Le tabagisme demeure toujours la cause principale de décès prématuré évitable dans le monde menant à plus de 7 millions de décès par an. Ce comportement est particulièrement préoccupant chez les jeunes adultes, chez qui la prévalence est la plus élevée parmi tous les groupes d'âge au Canada et dans de nombreux autres pays industrialisés. Plusieurs caractéristiques de l'environnement résidentiel, notamment la présence et la densité de commerces vendant du tabac et la présence d'accommodements aux fumeurs, ont été associées à l'initiation au tabagisme, à une prévalence plus élevée du tabagisme, à moins de tentatives d'arrêt et des taux de cessation tabagique plus faibles. Cependant, les résultats de ce corpus de recherche restent contradictoires. Je propose dans cette thèse que ces résultats contradictoires sont en partie dues à 1) l'absence d'une prise en compte des différentes trajectoires de comportements tabagiques, 2) l'absence d'études des associations entre des caractéristiques environnementales spécifiques et ces trajectoires comportementales, et 3) la possibilité que ces associations soient de tailles différentes en fonction de différentes échelles spatiales.

L'objectif général de cette thèse est donc d'avancer les connaissances sur les trajectoires de comportements tabagiques chez les jeunes adultes et sur leurs associations avec des caractéristiques de l'environnement résidentiel. Les objectifs spécifiques sont les suivants: 1) examiner si le tabagisme chez les jeunes adultes peut être mieux compris en examinant des trajectoires de comportements tabagiques à travers le temps, 2) examiner les associations entre ces trajectoires et des caractéristiques de l'environnement résidentiel, et 3) explorer comment ces associations peuvent varier en fonction de différentes échelles spatiales.

Les données analysées proviennent du *Interdisciplinary Study of Inequalities in Smoking* (ISIS), une étude de cohorte de 2093 jeunes adultes âgés de 18 à 25 ans résidant à Montréal, Canada, conçue dans le but d'examiner le rôle interactif des facteurs individuels et contextuels dans la production des inégalités sociales en matière de tabagisme. Trois mesures ont été

examinées: 1) trajectoires de comportements tabagiques observées rétrospectivement à deux ans d'intervalle, 2) trajectoires de comportements tabagiques observées prospectivement à deux ans d'intervalle, et 3) trajectoires de comportements tabagiques observées prospectivement à quatre ans d'intervalle. Les caractéristiques de l'environnement résidentiel ont été mesurées à partir de deux sources de données: des données obtenues par observation directe des rues où résidaient les participants et la base de données DMTI Inc. *Enhanced Points of Interest*©, qui fournit des informations sur un ensemble d'adresses géocodées incluant des détaillants de tabac. Des associations entre trajectoires de comportement tabagique et caractéristiques de l'environnement résidentiel ont été examinées à l'aide de modèles multiniveaux multinomiaux.

Les résultats de cette thèse mettent en relief la nécessité d'examiner des différentes trajectoires de comportements tabagiques chez les jeunes adultes et comment ces trajectoires peuvent être associées à des caractéristiques spécifiques des environnements résidentiels. Plus précisément, ces résultats mettent en évidence le rôle potentiel d'une plus grande présence et d'une plus grande densité locale et proximale de détaillants de tabac dans l'exacerbation de la variabilité dans les comportements tabagiques dans ce groupe d'âge, ainsi que dans la reconduction du statut de fumeur chez les fumeurs plus expérimentés. En outre, les résultats mettent en exergue l'influence potentielle d'une plus grande présence régionale d'accommodements aux fumeurs sur la persistance de trajectoires de tabagisme néfastes pour la santé. Finalement, la présence d'associations à des échelles spécifiques suggère que des processus liant ces caractéristiques et différentes trajectoires de comportements tabagiques peuvent opérer à différentes échelles spatiales.

Cette thèse contribue à la littérature sur les environnements résidentiels et le tabagisme en démontrant la valeur ajoutée d'examiner des trajectoires de comportements tabagiques et de la manière dont ceux-ci peuvent être influencés par des caractéristiques de l'environnement résidentiel. Cette recherche souligne la nécessité d'élargir l'examen des mesures du tabagisme afin d'inclure des trajectoires de comportements distincts qui intègrent l'évolution de la consommation de tabac au fil du temps et la manière dont ces trajectoires peuvent être associées aux

caractéristiques de l'environnement résidentiel. En outre, ces résultats mettent en relief l'importance de l'examen de différentes définitions spatiales pour faire progresser les connaissances concernant les échelles auxquelles ces caractéristiques peuvent exercer une influence plus marquée sur les trajectoires de comportements tabagiques. Pris ensemble, ces résultats peuvent aider à orienter la recherche et les interventions en santé publique visant à réduire le tabagisme chez les jeunes adultes en identifiant des trajectoires de comportements tabagiques spécifiques et des caractéristiques environnementales pouvant jouer un rôle important dans leur formation, ainsi que les échelles géographiques auxquelles les processus reliant les patrons et caractéristiques des environnements résidentiels peuvent opérer. Des recherches futures dans ce domaine devraient continuer à examiner l'influence des caractéristiques environnementales sur les trajectoires de comportements tabagiques ainsi que d'autres comportements de santé, non seulement chez les jeunes adultes, mais potentiellement dans d'autres populations.

Mots-clés : trajectoires de comportements tabagiques, jeunes adultes, environnements résidentiels, échelle spatiale, multiniveaux, comportement de santé

Abstract

Smoking continues to be the leading cause of preventable premature death worldwide, accounting for more than 7 million deaths per year. Tobacco use is of particular concern among young adults, who have the highest prevalence of smoking of all age groups in Canada and many other developed nations. Several residential environment features, including the presence and density of tobacco retail and the presence of smoker accommodation facilities have been found to be associated with smoking initiation, prevalence, quit attempts and cessation rates. However, findings from this research continue to be inconsistent. I propose in this dissertation that these inconsistencies are partly due to 1) a lack of consideration of the different smoking behaviour patterns that young adults may go through, 2) the paucity of research examining associations between these patterns and specific residential environment characteristics, and 3) the potential for these associations to be stronger at different spatial scales.

The overarching aim of this dissertation is to advance knowledge regarding smoking behaviour patterns among young adults and their association with residential environment features. The specific objectives are: 1) to examine whether smoking behaviour in young adults can be better understood by examining smoking behaviour patterns over time, 2) to examine associations between these patterns and residential environment features, and 3) to explore how these associations may vary in terms of presence and strength across different spatial scales.

Data stem from the *Interdisciplinary Study of Inequalities in Smoking* (ISIS), a cohort study of 2093 young adults aged 18 to 25 years at baseline residing in Montreal, Canada, conceived with the objective of examining the interactive role of individual and contextual factors in the production of social inequalities in smoking. Three different measures were examined: 1) retrospective 2-year smoking behaviour patterns, 2) prospective 2-year smoking behaviour patterns, and 3) prospective 4-year smoking behaviour patterns. Residential environment features were measured based on two sources: data obtained through direct observation of the street blocks where participants resided, and DMTI Inc.'s *Enhanced Points of Interest Database*©, which provides a collection of geocoded address points including tobacco retail stores. Associations

between smoking behaviour patterns and residential environment features were tested using multilevel multinomial models.

Findings from this dissertation highlight the need to examine distinct smoking behaviour patterns among young adults and how they may be associated with specific features of residential environments. Specifically, these results suggest a potential role of a greater proximal and local presence and density of tobacco retail in exacerbating variable smoking patterns in this age group as well as in sustaining tobacco use among persistent smokers. Moreover, they highlight the potential influence of a greater regional presence of smoker accommodation facilities on persistent smoking patterns. Finally, the presence of scale-specific associations suggests that processes linking these features and distinct smoking patterns may operate at different spatial scales.

This thesis contributes to the literature on residential environments and smoking by underscoring the added value of examining distinct smoking behaviour patterns and how these may be influenced by residential environment features. This research highlights the need to extend the examination of smoking outcomes to include distinct behavioural patterns that delve into how tobacco use may progress over time and how these patterns may be associated with residential environment features. Furthermore, these results highlight the importance of examining different spatial definitions to advance knowledge concerning the scales at which these features may exert a stronger influence on smoking behaviour patterns. Taken together, these findings can help orient public health research and intervention seeking to curb smoking among young adults by identifying specific smoking patterns and the environmental features that may play an important role in shaping them, as well as the geographic scales at which processes linking patterns and features may operate. Future research in this area should continue to examine how environmental features may influence smoking and other health behaviour patterns not only in young adults but potentially in other populations.

Keywords : Smoking behaviour patterns, young adults, residential environments, spatial scale, multilevel, health behaviour

Table of contents

Résumé i

Abstract iv

Table of contents vi

List of tables x

List of figures xii

List of abbreviations xiii

Acknowledgments xvi

CHAPTER 1: INTRODUCTION 1

1.1 Non-communicable diseases, health behaviours, and residential environments 3

1.2 Residential environments and health behaviour: an incomplete picture? 3

1.3 Young adulthood as a critical period for health behaviour change: the case of smoking 5

1.4 Research on environmental determinants of smoking behaviour patterns is limited 7

1.5. Spatial scale: an important issue to consider in studies of environmental factors and health behaviour patterns 8

1.6. Dissertation format 9

CHAPTER 2: LITERATURE REVIEW 11

2.1 Introduction 13

2.2 Why should we study smoking behaviour in young adults? 13

2.2.1. Trends in smoking among young adults are of significant concern 13

2.2.2. Beyond smoking prevalence: the need to examine smoking behaviour patterns over time 14

2.3 Determinants of smoking behaviour: the importance of environmental features 16

2.4 The need for knowledge regarding the potential influence of environmental features on smoking behaviour patterns 26

2.4.1 The emergent evidence of the potential influence of environmental features on specific smoking behaviour patterns 26

2.5 Definition and measurement of environmental features in health behaviour studies 28

2.5.1 The Modifiable Areal Unit Problem (MAUP) 29

2.5.2 The conundrum of identifying pertinent spatial units 31

2.5.3 Different approaches used to define spatial units in studies of contextual effects on health 32
2.5.4 Can administrative units be relevant to study contextual effects on health? 33
2.6 Objectives and expected contributions of this thesis 33
2.7 Research Hypotheses 34
CHAPTER 3: METHODS 36
3.1 Introduction 38
3.2 Study design, population and sampling 38
3.3 Operationalization of spatial scales used in this thesis 40
3.4 Residential environment features 43
3.5 Outcome measures 45
3.6 Covariates 48
3.7 Statistical Analyses 49
CHAPTER 4: RESULTS 51
ARTICLE 1 53
ABSTRACT 56
1. INTRODUCTION 57
2. METHODS 62
2.1. Study Sample 62
2.2. Description of Neighborhood Spatial Scales 63
2.3. Measures of Neighborhood Exposure 63
2.4. Outcome Measures 66
2.5. Covariates 66
2.6. Statistical Analyses 67
3. RESULTS 67
4. DISCUSSION 73
5. CONCLUSIONS 77
REFERENCES 79
ARTICLE 2 89
ABSTRACT 92

INTRODUCTION 93
METHODS 95
Sampling 95
Operationalization of Spatial Scales 95
Residential Environment Features 96
Outcome measure 97
Covariates 97
Statistical Analyses 98
RESULTS 99
DISCUSSION 102
CONCLUSIONS 105
REFERENCES 106
ARTICLE 3 114
ABSTRACT 117
INTRODUCTION 118
METHODS 120
Sampling 120
Tobacco retail presence and density 120
Smoker accommodation facilities 121
Smoking Patterns 121
Covariates 122
Statistical Analyses 122
RESULTS 123
DISCUSSION 127
CONCLUSION 130
REFERENCES 131
CHAPTER 5: DISCUSSION 136
5.1 A brief recapitulation of the context and objectives of this dissertation 138
5.2 Summary of main findings 139

5.3 Can smoking behaviour in young adults be better described and conceptualized by examining smoking behaviour patterns over time, beyond point-specific smoking outcomes? 140
5.4 Are specific residential environment factors associated with different smoking behaviour patterns? Does the presence and strength of these associations vary at different spatial scales? 142
5.4.1 Variable and persistent smoking behaviour: the role of local and proximal-level presence and density of tobacco retail 143
5.4.2 Presence of smoker accommodation facilities and smoking maintenance in young adults 146
5.5 Strengths and limitations 149
5.5.1 Strengths 149
5.5.2 Limitations 150
5.6 Implications for public health and health promotion 153
5.6.1 Extending research and surveillance beyond measures of smoking status 153
5.6.2 Restricting distribution of tobacco products 155
5.6.3 Outdoor smoking bans as a strategy to reduce smoking prevalence 157
5.7 Conclusion 159
BIBLIOGRAPHY 160
APPENDIX I: ISIS Information Letters and Consent Forms xviii
APPENDIX II: Ethical Approval xxvii
APPENDIX III: Diagram detailing the number of participants by time of survey and reasons for inclusion/exclusion from dissertation analytical samples xxxvi
APPENDIX IV: ISIS Neighbourhood Observation Grid xxxix
APPENDIX V: ISIS Individual Questionnaire T1 xliv
APPENDIX VI: ISIS Individual Questionnaire T2 lxvii
APPENDIX VII: Model Equations xci
APPENDIX VIII: Getis-Ord GI* Hot Spot Analysis of Smoker Accommodation Facilities by Sociological Neighbourhood ci
APPENDIX IX: Ghenadenik et al. (2018). Preventive Medicine 111: 35-40 civ
APPENDIX X: Curriculum Vitae cxxvi

List of tables

Chapter 2

Table 2.1. Studies of area-level compositional characteristics and smoking.....18

Table 2.2. Studies of local-level features operating through place-based practices and smoking.20

Table 2.3. Studies of local-level tobacco retail and smoking …….....22

Table 2.4. Studies of other local-level features operating through policy/regulation and smoking……...…….....25

Chapter 3

Table 3.1. Retrospective smoking behaviour pattern categories.…….....46

Table 3.2. Prospective smoking behaviour pattern categories.…….....47

Table 3.3. 4-year smoking behaviour pattern categories…….....48

Chapter 4

Article 1:

Table 1. Descriptive statistics of the analytical sample…….....69

Table 2. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from individual-level exposures among 2070 young adults living in Montreal, Canada in 2011–2012…….....70

Table 3. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from SN-level exposures among 2070 adults living in Montreal, Canada in 2011–2012…….....71

Table 4. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from CSSS-level exposures among 2070 adults living in Montreal, Canada in 2011–2012…….....72

Table 5. Results of fully-adjusted multinomial multilevel regression models predicting smoking trajectory over 2 years among 2070 adults living in Montreal Canada in 2011–2012…….....73

Article 2:

Table 1. Descriptive statistics for 1116 young adults from the ISIS cohort (Montreal, Canada, 2014)…….....99

Table 2. Descriptive statistics for environmental features measured at the street section level for 1116 young adults from the ISIS cohort (Montreal, Canada, 2014)…….....100

Table 3. Results of logistic 3-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014)……...101

Table 4. Results of logistic 2-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014).....102

Table 5. Results of fully-adjusted logistic 2-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014……..…….....102

Supplementary Materials…….....113

Article 3:

Table 1. Descriptive statistics for 1025 young adults from the *Interdisciplinary Study of Inequalities in Smoking* (Montreal, Canada, 2014)…….....124

Table 2. Results of multinomial multilevel regression models predicting smoking patterns over 4 years among 1025 young adults from *the Interdisciplinary Study of Inequalities in Smoking* using DA-level features as predictors (Montreal, Canada, 2014)…….....126

Table 3. Results of fully-adjusted multinomial multilevel regression models predicting smoking patterns over 4 years among 1025 young adults from the *Interdisciplinary Study of Inequalities in Smoking* (Montreal, Canada, 2014)…….....127

Chapter 5

Table 5.1. Smoking behaviour patterns among ever-smoker young adults in the ISIS cohort....140

List of figures

Chapter 3

Figure 3.1. Residential addresses of ISIS participants at baseline and follow-up (2011-2012, 2014)…….....40

Figure 3.2. Dissemination Areas on the Island of Montreal / Close-Up Plateau-Mont-Royal, Petite-Italie, Parc-Extension, Ville Mont-Royal.....41

Figure 3.3. Sociological Neighbourhoods on the Island of Montreal.....42

Figure 3.4. Health and Social Services Centres on the Island of Montreal….....43

Chapter 5

Figure 5.1. Two-year likelihood of being a non-smoker for fewer than 2 years by SN-level exposure to residential environment features…….....144

Figure 5.2. Four-year smoking behaviour patterns by DA-level density of tobacco retail.....145

Figure 5.3. 3 Two-year smoking behaviour patterns by CSSS-level of smoker accommodation……147

List of abbreviations

BRFSS	Behavioral Risk Factors Surveillance System
CARDIA	Coronary Artery Risk Development in Young Adults Study
CCDSS	Canadian Chronic Disease Surveillance System
CCHS	Canadian Community Health Survey
CI	Confidence interval
CTADS	Canadian Tobacco, Alcohol and Drugs Survey
CLSC	*Centre local de services communautaires*
CSSS	*Centre de santé et de services sociaux*
DA	Dissemination area
DSP	Direction de santé publique de Montréal
ISIS	Interdisciplinary Study of Inequalities in Smoking
MAUP	Modifiable areal unit problem
MCS	Millennium Cohort Study
MEGAPHONE	Montreal Epidemiological and Geographical Analysis of Population Health Outcomes and Neighbourhood Effects
NCD	Non-communicable diseases
NHANES	National Health and Nutrition Examination Survey
OR	Odds ratio
PA	Physical activity
POS	Point of sale
POSM	Point-of-sale marketing
RAMQ	*Régie de l'Assurance Maladie du Québec*
SEP	Socioeconomic position
SES	Socioeconomic status
SN	Sociological neighbourhood
US	United States

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CHAPTER 1: INTRODUCTION

1.1 Non-communicable diseases, health behaviours, and residential environments

Following the epidemiological transition (1), non-communicable diseases (NCDs) have been recognized as the main health challenge for the world's population (2). Modifiable health behaviours, chiefly tobacco and alcohol use, dietary habits, physical activity, and sexual practices weigh heavily on the burden of NCDs, accounting for approximately 50% of preventable premature morbidity and mortality in developed countries (3, 4).

Health behaviours are influenced by a variety of factors. Driven by a shift in focus from individual-level characteristics as central determinants of health behaviour to environmental-level factors as significant contributors to their adoption and maintenance (5-7), health and place research (often referred to as "neighbourhood effects research" (8)) has experienced fulgurant growth since the 1990s and is now an important field of inquiry for epidemiological studies. This literature highlights the importance of local social and physical environments, including areas where individuals live, work, study and play (5, 8, 9). Within these areas, residential-level features are known to play a central role in shaping health behaviours and outcomes in populations (10-12). These factors are often unequally distributed in urban settings, with a disproportionately higher presence of health-deterring features and a lower presence of health-promoting features in more socioeconomically disadvantaged areas (13), consequently playing an important role in the production of place-based health inequalities (14). A large body of research on places and health has uncovered associations between different residential-level features and a number of health behaviours and outcomes, including diet (15-17), physical activity (15, 16, 18, 19), risky sexual behaviour (20), and cardiovascular and cardiometabolic risk factors including smoking (21-23), above and beyond individual characteristics.

1.2 Residential environments and health behaviour: an incomplete picture?

The above-mentioned studies have made significant contributions to advancing knowledge regarding the potential influence of environmental features on health behaviours and outcomes. Nonetheless, important limitations have been highlighted in the recent literature (12). Two of these limitations are discussed in Arcaya et al's 2016 systematic review of neighborhood effects research in the United States (24): 1) a preponderance of cross-sectional designs, which precludes the examination of putative causal mechanisms, and 2) a reliance on single spatial unit types to

examine associations between environmental features and health outcomes, therefore failing to acknowledge potential challenges concerning scale-related issues including the well-known "modifiable areal unit problem" (25).

In addition to addressing these two limitations, I propose in this dissertation that research in this area also needs to examine 1) not only how local environments may be related to the incidence and prevalence of health behaviours but also how they may influence health behaviour patterns over time, and 2) how specific features within these environments may be differentially associated with distinct types of behavioural patterns. To date a large proportion of health and place studies have examined outcomes at specific points in time, such as initiation, prevalence and cessation of diet-related behaviours, alcohol consumption, physical activity, and smoking. However, whereas these studies are certainly valuable, these "snapshots" may only provide a partial understanding of environmental influences on health behaviour, chiefly given the potential instability of behavioural patterns. Consequently, research based on point-specific measures of health status may not provide sufficient information regarding behavioural patterns that may arise over time.

To date, most models (e.g.: Prochaska and Velicer's Transtheoretical Model (26)) implicitly or explicitly conceptualize health behaviours to progress through different stages. Nonetheless, some scholars have challenged this conceptual approach and propose that health behaviours evolve instead in terms of patterns (27, 28) that may not follow a stable progression, therefore being subject to considerable changes over time (29-35). Furthermore, behaviour change models generally assume that the influence of the different factors potentially playing a role in shaping these behaviours is fairly constant and hence similar across stages (28). However, several authors criticized this assumption and propose that health behaviour initiation, maintenance, and discontinuation may be influenced by different sets of determinants (27, 36) both at the individual (37) and environmental levels (38).

These limitations hinder our ability to identify potential determinants of distinct health behaviour patterns and can constitute a significant hurdle to the development of effective policies and interventions aiming to modify health behaviour. Therefore, research concerning the potential role of environmental factors in shaping *different health behaviour patterns* is needed. The

overarching aim of this dissertation is to advance knowledge regarding smoking behaviour patterns among young adults and their association with residential environment features. To this end, different behavioural patterns will be studied. This case is well-suited to achieve this goal due to the high prevalence of tobacco use in this age group and their variable smoking behaviour (30-32).

1.3 Young adulthood as a critical period for health behaviour change: the case of smoking

Public health is increasingly recognizing young adulthood (often defined as the period between 18-25 years of age) as a distinct and critical period within which health behaviours may be subject to changes and ultimately become entrenched (39). The transition from adolescence to adulthood is typically hallmarked by a series of major changes, which may include the pursuit of a higher education, the beginning of full-time employment, starting a family, and leaving the parental household. While these developmental changes take place, several health behaviours and outcomes may be initiated, stopped and/or can become established, including changes in physical activity, unhealthy diets, alcohol and drug use, and smoking (39-41).

The latter is a major public health concern for several reasons. First and foremost, tobacco use is the leading cause of preventable morbidity and mortality in Canada (42). Smoking is particularly problematic among young adults, not only because they have the highest smoking rates of all age groups (43), but also because in contrast to other populations, these rates have remained essentially unchanged in recent years (44). Second, even though most individuals begin to experiment with smoking at high-school age, the incidence of smoking among young adults is on the rise (45-47): several studies show that up to 30% of individuals initiate smoking during this period (46, 48-51). Finally, smoking behaviour may not yet be well established, since young adulthood is characterized by repeated shifts in outcomes, including transitions from experimental or occasional smoking to regular smoking, and from non-addicted to addicted smoking (47, 52).

Developmental transitions taking place during young adulthood are thought to influence smoking behaviour because of changes in residential, social, occupational, and educational settings (47, 52). These transitions may entail changes in exposure to environmental factors as well as shifts in social networks and a need to cope with incremental stress levels (47, 53, 54). Setting changes may not only influence smoking uptake but may also exacerbate variable smoking

behaviour patterns, and can ultimately contribute to establishing persistent smoking among those initiating tobacco use after age 18, as well as among individuals who first tried smoking as adolescents (47, 55). Since as discussed above determinants of smoking patterns including uptake, maintenance, switches between smoking and non-smoking periods and sustained cessation may be different from those of smoking initiation, prevalence and quit attempts (27, 28, 38), research concerning tobacco use in young adults must examine these different patterns in order to advance knowledge in this area.

The importance of young adulthood as a critical period for tobacco control policy and intervention has been recently recognized by the Montreal Public Health Department (Direction de santé publique de Montréal, DSP) in its 2017 Annual Report *"Le tabagisme chez les jeunes adultes: agir ensemble pour diminuer la prévalence"* (56). Several strategies are proposed in this document to achieve three main objectives: 1) to prevent smoking initiation, 2) to encourage, facilitate and sustain smoking cessation, and 3) to protect non-smokers from being exposed to second-hand smoke. Among these strategies, tobacco control policies and regulations such as limiting accessibility to tobacco retail, reducing exposure to tobacco marketing at the point of sale and restricting smoking in public places are important components of the DSP's plan of action.

Several tobacco control policies and legislative measures have been adopted in Canada since the 1980s, when bans on indoor smoking in certain venues such as schools and hospitals were enacted (56). These include increases in taxes on tobacco products, comprehensive indoor smoking bans, restrictions on advertising and promotion including point-of-sale marketing bans and restrictions regarding retail store locations (57). More recently, other measures have been adopted including the prohibition of smoking in outdoor patios and terraces in hospitality venues in most Canadian provinces including Quebec (57, 58). Nonetheless, other potential measures, notably those concerning local-level reductions in the number and concentration of tobacco-selling stores and comprehensive bans on all forms of point-of-sale marketing (e.g.: signs announcing price promotions) have yet to be enacted in all Canadian jurisdictions (57).

Taking the Montreal Public Health Department document as an example that highlights the need to address different smoking behaviour patterns (preventing initiation, fostering and

sustaining cessation, preventing exposure to smoking among non-smokers), and keeping in mind the current policy and legislative context, I propose in this dissertation that the examination of associations between features of areas surrounding residential addresses (which I call in this dissertation "residential environment features") and discrete *smoking behaviour patterns* should become a key area of focus in health promotion studies. The current knowledge gaps limit both the understanding of the potential influence of environmental factors on smoking behaviour and the implementation of effective public health policy and intervention, chiefly by not paying enough attention to different behaviour patterns that may explain a similar prevalence of smoking in different territories.

The potential shortcomings of focusing exclusively on point-specific smoking outcomes can be illustrated in the following example, where two (fictitious) areas have the same smoking prevalence (e.g.: 25% in both), however each composed of a different mix of new and persistent smokers (e.g.: in the first area 70% are persistent smokers and 30% are new smokers, whereas the reverse may be true in the second area). Since features that may influence new smoking uptake (e.g.: proximity to tobacco retail stores) may differ from those potentially influencing persistent smoking (e.g.: presence of smoking accommodation facilities), public health action must acknowledge these dissimilarities and the risk factors associated with each smoking behaviour pattern in order to effectively impact these determinants in both areas. However, few studies capable of providing information regarding these differences exist to date.

1.4 Research on environmental determinants of smoking behaviour patterns is limited

Recent years have witnessed an increase in studies seeking to advance knowledge on environmental features and their potential influence on distinct health behaviour patterns. Most of this research has focused on energy expenditure-related behaviours and outcomes (e.g.: walking, physical activity, diet, obesity) and has found associations between specific residential environment features and different behaviour patterns. For example, evidence from a longitudinal study of neighbourhood-level green space and recreational walking initiation in Australia showed that positive perceptions of presence of and proximity to green spaces were significantly associated with a higher likelihood of walking maintenance over four years, but not with walking initiation (59). In another example, a study conceived with the objective of examining potential differences

in predictors of physical activity (PA) intensity and time of the week indicated that among others, environmental features including presence and distance to parks, sports venues, and other facilities, land-use mix and walkability were associated with weekend changes in PA, but no associations were detected with weekday changes in PA levels (60). Finally, a 2015 series of articles on obesity (61) highlighted that the uptake of healthy eating may be influenced by local norms and values (which may also impede uptake), but the maintenance of this behaviour may be more strongly influenced by the local offer of healthy and unhealthy food sources.

Although these examples did not examine substance abuse-related behaviours, as highlighted above several health behaviour change theories propose that distinct patterns may be influenced by different sets of determinants. Therefore, these studies are useful to illustrate how distinct environmental features may be associated with a specific health behaviour pattern (e.g.: presence/proximity of green space was associated with walking maintenance but not with initiation).

Whereas the growing literature on residential environments and energy expenditure-related behaviours and outcomes has contributed to improve our understanding of the potential role of environments in shaping distinct behaviour patterns, little research exploring links between these features and substance abuse behaviour patterns (including smoking) exists to date. Nonetheless, as in the energy expenditure literature, some studies (e.g.: (62, 63)) suggest that characteristics of residential environments have indeed the potential to influence specific smoking behaviour patterns.

1.5. Spatial scale: an important issue to consider in studies of environmental factors and health behaviour patterns

Several conceptual and methodological issues should be taken into consideration to adequately examine the potential influence of environmental features on health behaviour patterns. Since mechanisms underlying feature-pattern associations may operate at different scales (11), an important consideration is the need to explore scale-dependent associations. As will be discussed in Chapter 2, there are inconsistencies in the results reported in the literature on places and

smoking. These inconsistencies may be at least in part due to differences in the spatial units chosen to examine associations between environmental factors and health behaviour outcomes.

Spatial scale issues concerning the conceptualization and operationalization of local-level areas have long been at the core of health geography research (64-66). Nonetheless, this is less so in epidemiologic studies of places and health. Hence, in line with calls by to pay attention to spatial scale issues (11, 67, 68) this dissertation will examine scale-related differences in associations between residential environment features and smoking behaviour patterns.

1.6. Dissertation format

The core of this dissertation consists of four chapters. Chapter 2 presents a literature review of studies of residential environment features and smoking. In this chapter, I discuss the importance of studying smoking behaviour in young adults, to then provide a detailed review of the existing literature on residential environments and smoking, and a discussion of the main shortcomings of this body of research. I end Chapter 2 with an introduction to the conceptual and methodological challenges related to the definition and measurement of environmental features, and a discussion of the approaches that may be used to select pertinent spatial units to examine the potential influence of residential environments on health behaviour.

Chapter 3 presents an overview of the methodological approach used in this dissertation. This chapter includes details regarding the main sources of data for the analyses included in this thesis, as well as information on spatial unit definitions, residential environment features, outcome measures, covariates, and analytical approaches.

Chapter 4, the results chapter, is comprised of three scientific articles. The first, *"Beyond Smoking Prevalence: Exploring the Variability of Associations between Neighborhood Exposures across Two Nested Spatial Units and Two-Year Smoking Trajectory among Young Adults"* examines scale-related differences in associations between two residential environment features, presence of tobacco retail stores and presence of smoker accommodation facilities and a retrospective measure of smoking behaviour in young adults. The second, *"Residential environments and smoking behaviour patterns among young adults: A prospective study using*

data from the Interdisciplinary Study of Inequalities in Smoking cohort" examines the potential influence of these two features, as well as of density of tobacco retail on prospectively-measured smoking behaviour patterns over the course of two years, Finally, the third article, *"Smoking behaviour in young adults: A study of 4-year smoking patterns and residential presence of features facilitating smoking using data from the Interdisciplinary Study of Inequalities in Smoking cohort"*, examines four-year smoking behaviour patterns, providing detailed information regarding the variable nature of smoking behaviour in young adults, and how environmental features may contribute to exacerbate this variability.

Finally, Chapter 5 discusses the significance of findings, strengths and limitations, as well as the contributions of this dissertation to the health promotion literature, and potential directions for future research as well as implication for policy and practice.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter will review the literature supporting the relevance of studying smoking behaviour patterns among young adults and their association with residential environment features. This review has two objectives: 1) to present an overview of how smoking behaviour and its association with residential environments has been examined to date, to then go on to identify the main shortcomings of this literature, and 2) to identify methodological issues related to studies of place effects on smoking, chiefly the need for consideration of spatial scale issues, and the approaches that may be used to address them analytically. These two aims served to inform the specific objectives of this dissertation.

Different searches were performed using the MEDLINE and PubMed databases, as well as the grey literature including but not limited to government reports, research reports, and theses covering issues related to smoking behaviour. To achieve the first objective, I started with a review of the most current trends in smoking among young adults to then go on to focus on research published in the past 20 years regarding the potential role of environmental features in shaping geographically-patterned differences in smoking behaviour. For the second objective I reviewed the literature concerned with the definition and measurement of environmental-level features in health behaviour studies. Specifically, I searched for studies reporting on whether and how spatial scale issues have been considered empirically as well as the potential sources of measurement error related to the lack of specific consideration for these issues, to then focus on the potential approaches that may be taken to mitigate these shortcomings.

2.2 Why should we study smoking behaviour in young adults?

2.2.1. Trends in smoking among young adults are of significant concern

Tobacco use contributes to an estimated 37,000 deaths per year in Canada (69). Even though smoking prevalence has declined significantly since the 1960s, when approximately 50% of the Canadian population aged 15 years or older smoked, the rate of decrease has slowed down significantly in recent years (70). These findings mirror those in the United States, where a marked slowdown in the rate of decline of tobacco use has occurred since the mid-2000s (71).

Smoking rates are particularly concerning among Canadian young adults. In 2015, 18.3% of the population aged 20-24 years old reported daily or occasional smoking, whereas prevalence in the general population aged 15 years or older was 13.0% (43). This higher prevalence points to the fact that many individuals initiate smoking during young adulthood. This can be evidenced in a study of a cohort of students in Montreal (46), which found that 14% of youth who took up smoking before 24 years of age did so after high school. Similar findings were reported in the United States: the 2014 Report of the Surgeon General (72) estimated that 13% of daily smokers first tried a cigarette after 18 years of age. Furthermore, not only does significant initiation take place during young adulthood, but also, as reported by Quebec's Ministry of Health and Social Services, many individuals move to regular smoking during this period: in this province, 37% of daily smokers moved to everyday smoking between the ages of 18 and 29 (56). Moreover, as reported in a 2012 systematic review (49) young adult initiation rates are surpassing those of adolescents, having remained essentially unabated since 2001 (73).

These findings require attention, because this population group tends to be overlooked in tobacco control efforts (46) and therefore underutilizes evidence-based cessation treatments (74). This, in spite of evidence suggesting that young adulthood may be a critical period for daily smoking initiation and therefore important for smoking cessation intervention (50).

2.2.2. Beyond smoking prevalence: the need to examine smoking behaviour patterns over time

Incidence-based outcomes such as smoking initiation and cessation, and their potential determinants have long been at the core of the tobacco use literature: the reduction of smoking initiation rates (e.g.: towards the creation of a "tobacco-free generation" (75, 76)) and the increase of successful quit attempts are crucial to the achievement of smoke-free goals (77). To this end, advancing knowledge of the determinants of initiation and cessation is central to research and intervention in this area. For example, age to smoking initiation is known to be linked to future smoking patterns: earlier initiation is associated with a higher likelihood of future established smoking (78, 79), as well as with a lower likelihood of successful quitting (80). Therefore, interventions targeting early smoking initiation can be effective approaches to the reduction of population-level smoking rates.

However, an exclusive focus on incidence-based outcomes can only provide partial knowledge regarding how health behaviours evolve over time, and of their potential determinants and interventions most effective to change them. This is because although incident events constitute important behavioural milestones (46, 81), a substantial body of knowledge highlights a widespread inability to sustain newly-initiated health behaviours over time (36). Moreover, this literature underscores important theoretical and conceptual differences between the initiation and cessation of health behaviours and their maintenance, which in turn involve distinct intra-personal, interpersonal and contextual processes and determinants (27, 28, 37, 38).

A growing number of studies provide evidence of the potential for different determinants to distinctly influence the initiation and maintenance of health behaviours. For example, health psychology research shows that although there seems to be a strong relationship between self-efficacy and quit attempts, this construct is not a good predictor of sustained smoking cessation (27). Similar differences between determinants of initiation and maintenance (including individual and contextual-level factors) have been reported in a study of green space and initiation and maintenance of recreational walking (59), as well as in a literature review of determinants of physical activity among older adults (82).

Furthermore, as mentioned in the introductory chapter, although most theoretical models assume behaviours to progress from initiation to maintenance (and eventually cessation) in a fairly linear fashion (28, 36), several conceptual approaches (27, 28, 37, 38) and substantial empirical evidence point to the existence of variable behavioural patterns across different health outcomes and populations (29-35). Specific to smoking, a growing number of studies have indeed reported the existence of different types of *smoking behaviour patterns* over time, which are far from following linear progressions from initiation to maintenance or cessation (31, 83-85).

The identification and examination of differences in smoking behaviour patterns is particularly important among young adults. As mentioned in the previous chapter, this population experiences significant changes in smoking behaviour over time. Contrary to hypotheses postulating that smoking status becomes largely fixed after high school age, Hammond (47) proposed that young adults go through variable smoking patterns, with significant smoking uptake taking place during

this period and in many cases shifting repeatedly between a smoker and a non-smoker status, and between daily and occasional smoking. As a result, regular smoking habits may only develop later in life (86). These variable patterns have been portrayed in a 2004 study of changes in smoking behaviour over a 4-year period among a cohort of college students (32). Results at follow-up showed that 13% of daily smokers at baseline ceased to smoke and 28% changed their status from daily to occasional smokers. Also, 14% of occasional smokers at baseline became daily smokers whereas 51% ceased to smoke, and 11% of non-smokers at baseline initiated occasional smoking. Finally, 87% of smokers at baseline and 50% of occasional smokers at baseline continued to smoke after 4 years.

The above-described variability in young adults' smoking behaviour points to the importance of going beyond the examination of discrete measures of smoking initiation, prevalence and quit attempts, as they may only provide partial information concerning smoking behaviour. This is because these measures may fail to capture developing and/or variable behavioural patterns that may only become well-established later on. Moreover, in light of the potential for different determinants to influence distinct health behaviour patterns (27, 36), associations between these determinants and specific smoking behaviour patterns must be examined, as they can provide important information regarding their influence on smoking in this population. In light of these issues, I propose in this dissertation that in order to effectively curb smoking in young adults, public health needs to devote efforts to the identification and examination of smoking behaviour patterns and their potential determinants. These patterns and their association with environmental features will be examined in the empirical articles that are part of this dissertation.

2.3 Determinants of smoking behaviour: the importance of environmental features

Although often studied as individual phenomena, when measured at the population level, health behaviours including smoking can be conceptualized as collective "health lifestyles" (87), which *"[…]comprise interacting patterns of health-related behaviours, orientations and resources adopted by groups of individuals in response to their social, cultural and economic environment"* (88). In other words, whereas health behaviours in individuals are often thought to be self-regulated by intrapersonal processes, group-level behavioural patterns are thought to be strongly influenced by environmental factors that may constrain or enable self-regulation.

A significant body of research provides evidence of marked geographically-patterned social inequalities in smoking among different population groups including young adults: those living in socioeconomically disadvantaged areas are more likely to be smokers and less likely to successfully quit than their pairs from advantaged areas (89-96). Place-based social inequalities in smoking are readily evident in the Montreal Metropolitan Region: in 2012 the prevalence of smoking among young adults who lived in deprived areas almost doubled that of those who lived in advantaged areas (24.4% vs. 13.3%). Marked differences by neighbourhood socioeconomic level are also evident for smoking cessation rates (97). These geographically-patterned inequalities are not random, but rather the result of differential distributions of health-relevant resources (10). For example, studies show that tobacco and alcohol retail stores are disproportionately concentrated in more disadvantaged areas (98-102) whereas the reverse is true for recreational and physical activity facilities (103-105). These local-level differences in distribution and accessibility to health-relevant resources, whether health-promoting (e.g.: recreational and physical activity facilities) or health-deterring (e.g.: tobacco and alcohol retail stores) may have a significant impact on population groups above and beyond their individual characteristics (7, 67).

Local-level differences in smoking outcomes have been extensively studied in the literature. A large proportion of studies of place-based disparities have examined associations between smoking prevalence and compositional characteristics of local areas, including average neighbourhood income (91, 106-109), average occupation type (92, 106-111), and average educational attainment (92-94, 106, 107, 110, 111). Also, other compositional characteristics such as average neighbourhood wealth (107) and average housing status (111) have been explored (see Table 2.1 below for details).

Table 2.1 Studies of area-level compositional characteristics and smoking

Author	Objective	Study Population	Main Predictors	Main Outcomes	Design	Main Results
Reijneveld, 1998	To examine associations between area-level deprivation and differences in smoking prevalence	Residents of Amsterdam, Netherlands (n 5121)	Area-level deprivation	Smoking prevalence	Cross-sectional	Age and gender-adjusted prevalences of smoking were higher in deprived urban areas
Duncan et al., 1999	To examine associations between ward-level deprivation and smoking	British Health and Lifestyle Survey (n 9003)	Ward-level deprivation	Smoking status	Cross-sectional	Individuals residing in areas with higher ward-level deprivation were more likely to be smokers
Ross, 2000	To examine associations between area-level socioeconomic status and walking, exercising and smoking	Illinois Community, Crime and Health survey (aged 18+, n 2482)	Poverty, education, and racial and ethnic composition in respondents' census tract	Smoking prevalence	Cross-sectional	Men in poor neighbourhoods were more likely to smoke than those in less disadvantaged places. neighbourhood context was not associated with women's likelihood of smoking.
Chuang et al., 2005	To examine associations between neighbourhood level socioeconomic status and convenience store concentration and individual-level smoking	Participants from the Stanford heart disease prevention programme (aged 25-74) in Northern California (n 8121)	Neighbourhood level socioeconomic status and convenience store concentration	Smoking status	Cross-sectional	Individual-level smoking status was positively associated with a lower neighbourhood SES and higher convenience store concentration
Harman et al., 2006	To examine socioeconomic gradients cigarette smoking status by age among women aged 20–34	UK's Southampton Women's Survey (aged 20-34) (n 12398)	Education level	Smoking status	Cross-sectional	Socioeconomic gradients in ever-smoking were marked but stable across age groups. Quitting was more prevalent in higher SES groups. Current smoking rates were higher in older age groups
Datta et al., 2006	To examine associations between smoking and individual, neighbourhood, and state socioeconomic characteristics	Black Women's Health Study (n 41726)	Individual, neighbourhood, and state-level poverty	Smoking prevalence	Cross-sectional	In fully-adjusted models, higher neighbourhood poverty was associated with increased smoking prevalence. State of residence was also significantly associated with prevalence of current smoking
Virtanen et al., 2007	To examine associations between average household income and local level crime rates and smoking status and intensity	Cohort of Finnish municipal employees (n 23008)	Local-level average household income and average crime rates	Smoking status, smoking intensity	Cross-sectional	Current smoking and smoking intensity were positively associated with low local area income rates and with high local-area crime rates was also associated with current smoking. Being an ex-smoker was less likely among residents in areas with low average household income and a high crime rate
Federico et al., 2007	To examine socioeconomic inequalities in smoking initiation and cessation and resultant inequalities in smoking prevalence	Italian National Health Interview Survey of individuals born between 1940-1969 (n 58727)	Education level	Smoking status, smoking initiation, smoking cessation	Repeated cross-sectional	Inequalities in lifetime smoking prevalence increased across successive birth cohorts. At age 40, lower-educated persons in the youngest cohort reported on average 1-5 years of additional exposure to regular smoking vs. higher-educated persons. Inequalities in smoking prevalence increased among both men and women because of widening inequalities in initiation rates
Doku et al., 2010	To investigate socioeconomic differences in relation to adolescent smoking in Finland, and to examine whether these differences increased within a 30-year period	Participants from the Finnish Adolescent Health and Lifestyle Survey (aged 12-18)	Parental occupation, parental education, family structure, school performance, particpants' education	Smoking status	Repeated cross-sectional	Socioeconomic differences in smoking measured by familial SES or individual social position persisted over time, with higher rates in lower SES groups. Differences between groups assessed by individual social position increased over time
Chahine et al., 2011	To examine individual and contextual factors that best explain overall variance in smoking in the United States	Participants of the US CPS TUS household survey (aged 18+, n 227428)	Age, gender, income, race, employment status, education, occupation, family status, state-level tobacco taxes, presence of smoking bans, previous state-level smoking prevalence	Smoking status	Cross-sectional	Various sociodemographic variables were significant predictors of smoking, explaining 67% of variance at the core statistical area level alone and 41% at the state level. Other predictors (e.g.: indoor smoking legislation and cigarette taxes) contributed to explain variability in smoking prevalence

Rather than focusing on structural characteristics, this body of research is guided by theoretical frameworks that propose that individuals who have similar socioeconomic characteristics tend to cluster in specific areas: differences between clusters are thought to explain differences in health outcomes (7).

Nonetheless, even though area-level socioeconomic characteristics can play a significant role in shaping smoking behaviour, there is considerable evidence highlighting the importance of environmental factors in terms of their potential to influence smoking outcomes. Pearce and colleagues (2012) have proposed two main sets of pathways through which environmental features can influence smoking behaviour: place-based practices and place-based regulation and policy (112). The first set comprises different practices and behaviours that arise through social interaction. These include the influence of social capital and social networks on norms and values regarding smoking behaviour (e.g.: whether smoking is tolerated in certain contexts), and measures of crime, disorder and stress. The second set encompasses policies and regulations that enable or constrain smoking behaviour. These include initiatives to promote cessation, smoking bans, restrictions to the sale and advertisement of tobacco products, and "urban renewal" interventions (e.g.: housing improvement initiatives).

Associations between environmental features and smoking outcomes thought to operate through place-based practices have been extensively examined, mainly using measures of neighbourhood-level social capital including neighbourhood trust, the presence of a supportive social environment, social cohesion, and social norms. This feature is thought to influence smoking through a variety of mechanisms including a more rapid diffusion of health information and a higher likelihood of adoption of healthy (or unhealthy) behaviours (113), increased social control over deviant behaviours (114), improved access to local services and amenities (114), psychosocial processes related to affective support, self-esteem and mutual respect (115), perceptions of poor safety, feelings of discomfort and threat, and anti-social behaviours (116). Nonetheless, empirical results regarding the potential role of social capital in influencing smoking behaviour are inconsistent. Whereas several studies examining these features have reported associations with smoking prevalence/status and/or cessation outcomes (117-124), others found no significant

associations with either smoking prevalence/status, risk of relapsing, or changes in smoking status (119, 121, 125-129). (see Table 2.2 below for details).

Table 2.2 Studies of local-level features operating through place-based practices and smoking

Author	Objective	Study Population	Main Predictors	Main Outcomes	Design	Main Results
Patterson et al., 2004	To examine associations between social cohesion, neighbourhood safety, and home safety and smoking status	Participants of the Minneapolis, Minnesota Survey of the Health of Adults, the Population, and the Environment (aged 18 , n=10617)	Social cohesion, neighbourhood safety, home safety	Smoking status	Cross-sectional	Higher area level social cohesion and of neighbourhood safety were associated with a lower likelihood of smoking
van Lenthe and Mackenbach, 2006	To explore associations between physical neighbourhood stressors and smoking, and their contribution to neighbourhood and individual socioeconomic inequalities in smoking	Eindhoven, Netherlands residents aged 20 (n=9062)	Neighbourhood socioeconomic environment (aggregated education, occupation level, and employment status); neighbourhood stressors (physical decay, required police attention, noise pollution from traffic, and population density)	Smoking status	Cross-sectional	Residents living in most disadvantaged neighbourhoods were more likely to be smokers. Increases neighbourhood stress scores were associated with smoking status independently of neighbourhood environment
Miles, 2006	To investigate the influence of neighbourhood physical disorder on smoking behaviour, and the extent to which it is mediated by perceptions of safety	Participants of the LARES survey, conducted in 8 European cities (n=5784)	Neighbourhood disorder (presence of graffiti and litter, absence of vegetation on facades, balconies or windows), perceptions of safety	Smoking status	Cross-sectional	Participants living in areas with high neighbourhood disorder were more likely to be smokers. Only a small part of the effect of neighbourhood disorder was mediated by perceptions of safety
Siahpush et al., 2006	To examine associations between smoking status and income inequality, relative deprivation, perception of relative material well-being and community-level social capital	Melbourne, Australia residents aged 18 (n=2762)	Objective and perceived income inequality, objective relative deprivation, perceived relative material well-being, individual and community level social capital	Smoking status	Cross-sectional	Current smoking was associated with a higher level of perceived income inequality, lower perception of relative material well-being and living in a community with a lower degree of trust and safety
Echeverria et al., 2008	To examine associations between measures of neighbourhood problems and neighbourhood social cohesion with different outcomes including smoking	Participants of the Multi-Ethnic Study of Atherosclerosis (MESA)	Neighbourhood problems (composite measure including excessive noise, heavy traffic/speeding cars, lack of access to adequate food shopping, lack of parks/playgrounds, trash/litter, no sidewalks/poorly maintained sidewalks, and violence), neighbourhood social cohesion	Smoking status	Cross-sectional	In models adjusted for individual-level covariates, participants living in the least problematic neighbourhoods were significantly less likely to be current smokers. Those residing in less socially cohesive neighbourhoods were more likely to be current smokers
Sapag et al., 2010	To examine associations between social capital and tobacco use in low-income neighbourhoods	Survey of adults residing in 4 low-income neighbourhoods in Santiago, Chile (aged 18 , n=781)	Neighbourhood social capital (perceived trust in neighbors, perceived trust in organizations, reciprocity within the neighbourhood, neighbourhood integration, social participation)	Smoking status, number of cigarettes/day	Cross-sectional	Trust in neighbors was inversely associated with smoking status, and with number of cigarettes smoked
Giordano and Lindstrom, 2011	To examine associations between changes in social capital and smoking behaviour	Participants of the British Household Panel Survey (n=10512)	Social capital (social participation)	Change in smoking behaviour	Longitudinal	Continued membership in local groups was associated with a higher likelihood of being a new non-smoker at follow-up. Continued lack of membership in local groups was associated with a higher likelihood of being a new smoker at follow-up. No other associations were detected
Lin et al., 2011	To examine associations between perceived neighbourhood cohesion and alcohol, tobacco and cannabis consumption	Participants of the New Zealand Health Behaviours Surveys on Drugs and Alcohol (aged 13-65, n=14757)	Neighbourhood cohesion	Smoking status, number of cigarettes/day	Cross-sectional	Higher perceived neighbourhood cohesion levels were associated with a decrease in the probability of tobacco use and of the amounts consumed
Shareck and Ellaway, 2011	To examine associations between objective and subjective masures of neighbourhood crime and residents' smoking behaviour	Participants of the West of Scotland Twenty-07 Study (n=2459)	Objective (police-recorded) and subjective neighbourhood crime rates	Smoking status, smoking intensity	Cross-sectional	Individuals residing in areas characterized by high objective (police-recorded) crime rates or high subjective crime rates in their neighbourhood were more likely to be current smokers. Associations were somewhat stronger for police-recorded crime than for perceived crime
Aslund and Nilsson, 2013	To examine associations between social capital and substance use among adolescents	Participants (aged 13-18) of the Vestmandland, Sweden Survey of Adolescent Life (n=7757)	Neighbourhood social capital, neighbourhood general social trust	Smoking status	Cross-sectional	Lower levels of neighbourhood social capital and neighbourhood social trust were associated with higher odds of being a current smoker

Many other studies have examined associations between environmental features and smoking thought to operate through policy and regulation pathways. Among these, one of the most extensively studied is the *proximity and/or density of tobacco retail stores*. Most of this body of research reported positive associations between proximity and a higher density of tobacco retail stores and smoking prevalence (101, 107, 130-136), as well as negative associations with quit attempts (134, 137-140). Associations with other outcomes have also been reported, including smoking initiation (141, 142), experimental smoking (62), susceptibility to future smoking (143), risk of relapse (144), and continued abstinence (145). Nonetheless, in contrast with these results, several other studies have not found any significant associations between proximity or density of tobacco retail stores and some or all of the smoking outcomes being investigated (62, 101, 135, 140, 144, 146-149). Of note, whereas earlier studies of tobacco retail and smoking had mostly relied on cross-sectional designs, most recent studies have used longitudinal approaches (139-141, 144-146, 149, 150). (See Table 2.3 below for details).

Table 2.3 Studies of local-level tobacco retail and smoking

Author	Objective	Study Population	Main Predictors	Main Outcomes	Design	Main Results
Pokorny et al., 2003	To examine smoking initiation and maintenance among students grades 6-8	US students grades 6-8 based on the Tobacco Access Project's Student Survey (n=5234)	Number of retailers who illegally sold tobacco per 1,000 youth in the community, density of tobacco retailers per youth population	Smoking initiation, smoking maintenance	Cross-sectional	Higher levels of retail tobacco availability were associated with increased odds of youth smoking initiation but not with maintenance of smoking
Chuang et al., 2005	To examine associations between neighbourhood level socioeconomic status and convenience store concentration and individual-level smoking	Participants from the Stanford heart disease prevention programme (aged 25-74) in Northern California (n=8121)	Neighbourhood level socioeconomic status and convenience store concentration	Smoking status	Cross-sectional	Individual-level smoking status was positively associated with a lower neighbourhood SES and higher convenience store concentration
Novak et al., 2006	To examine associations between tobacco outlet density and youth cigarette smoking	Chicago (US) residents aged 11-23 (n=2116)	Census tract-level tobacco outlet density	Smoking status	Repeated cross-sectional	Participants in areas at the highest tobacco outlet density were more likely to have smoked in the past month compared with those living at the lowest density areas. Results did not differ significantly between minors and those legally permitted to smoke
Henriksen et al., 2008	To examine associations between density and proximity of tobacco outlets and retail cigarette advertising around high schools and their association with school smoking prevalence	Schools participating inf the 2005-2006 California Student Tobacco Survey (n=135)	Density and proximity of tobacco outlets and presence of retail cigarette advertising	School-level smoking prevalence	Cross-sectional	Prevalence of current smoking was higher at schools in areas with the highest tobacco outlet density. Density of retail cigarette advertising was similarly associated with high school smoking prevalence. Neither presence of a tobacco outlet within 1000 ft of a high school nor distance to the nearest tobacco outlet from school was associated with smoking prevalence
McCarthy et al., 2009	To examine experimental and established smoking among middle and high school students and their association with density of tobacco retail around schools	Adolescents participating in the California Student Tobacco Survey in 245 public schools (n=19306)	Tobacco retail density and proximity	Established smoking, experimental smoking	Cross-sectional	Density of tobacco retail was associated with experimental smoking among high schools students in urban areas. No associations with established smoking were detected
Pearce et al., 2009	To examine associations between geographical accessibility to tobacco outlets and individual smoking behaviour	Participants of the New Zealand Health Survey of adults (aged 15 , n=12529)	Distance (travel time) to nearest tobacco outlet	Smoking status	Cross-sectional	No associations between residential accessibility to tobacco outlets and smoking status were detected in fully-adjusted models
Chan and Leatherdale, 2011	tobacco retail density surrounding schools and social smoking influences and smoking susceptibility among youth never smokers, and occasional/daily smoking among current smoker	Grade 9-12 students in Ontario, Canada (n=25893)	Tobacco retail density surrounding schools, social smoking influences	Smoking susceptibility (for never smokers), occasional/daily smoking (for current smokers)	Cross-sectional	Among never smokers, the number of tobacco retailers surrounding a school was associated with a higher likelihood being susceptible to future smoking. Also, being surrounded by smoking family members and close friends was associated with a higher risk of future smoking among never smokers and with a higher likelihood of being an occasional or daily smoker
Reitzel et al., 2011	To examine the influence of tobacco outlet density and residential proximity to tobacco outlets on continuous smoking abstinence 6 months after a quit attempt	US adult smokers from Houston, Texas (aged 21 , n=414)	Residence-centered tobacco retail density within 500m, 1km and 3km buffers, presence of tobacco outlets within 250m and 500m from participants' homes	Biochemically verified smoking abstinence at weeks 1, 2, 4, and 26 after quitting	Longitudinal	Participants residing <250m or <500m from the closest tobacco outlet were less likely to be abstinent, No associations between tobacco retail density and smoking abstinence were detected
Scully et al., 2013	To examine associations between density of tobacco retail and adolescent smoking behaviour	Australian secondary school students aged 12–17 (n=2044)	Tobacco retail density within a 500m radius around schools	Past-month smoking, number of cigarettes smoked	Cross-sectional	Higher tobacco retail densities were associated with a higher numbers of cigarettes smoked in the previous seven days among students who smoked in the past month. No associations between between this feature and past-month smoking were detected
Johns et al., 2013	To examine associations between exposure to tobacco retail outlets and smoking initiation in a racially diverse urban setting	Participants of the NYC Youth Risk behaviour Survey (high school students grades 9-12, n=-8633)	Exposure to retail tobacco marketing (times/week shopping at pharmacies, delis, or bodegas)	Smoking initiation	Cross-sectional	Participants exposed to tobacco retailers were more likely to have initiated smoking. Adolescents exposed to tobacco retail outlets ≥2 times/week were more likely to initiate smoking
Kirchner et al., 2013	To examine associations between real-time geospatial exposure to tobacco outlets and subjective craving to smoke and smoking cessation	Adult smokers (aged 18) residing in Washington, DC (n=475)	Daily frequency of exposure to tobacco retail outlets	Real-time subjective cravings, smoking cessation	Longitudinal	Lapsing was significantly more likely on days with any tobacco outlet contact, and increasingly likely as the number of daily outlet contacts increased. High levels of craving were more directly associated with lapse outcomes
Lipperman-Kreda et al., 2014	To examine associations between youth cigarette smoking and proximity/density of tobacco outlets around youth homes and schools	California households with youth aged 13-16 at baseline (n=832)	Tobacco outlet proximity and density around youth homes and schools	Past-30-day cigarette smoking frequency	Cross-sectional	Youth residing in areas with greater densities of tobacco outlets (0.75 and 1-mile buffers) were more likely to smoke more frequently. Tobacco outlet densities and proximity to schools and proximity to homes were not associated with youths past-30-day smoking frequency
Chalton et al., 2014	To examine associations between proximity to tobacco retail and smoking behaviours among smokers seeking treatment.	Clients of a nicotine dependence clinic in Toronto, Canada (n=734)	Distance to nearest tobacco store, number of outlets within a 250m buffer	Cigarettes/day, successful abstinence, time to 1st morning cigarette, lifetime quit attempts	Cross-sectional	Participants residing in areas with >1 tobacco outlet with 250m were less likely to be abstinent and less likely to have a longer time to first cigarette. Smokers residing in areas with >1 tobacco outlet with 250m smoked 3.4 cigarettes more per day than smokers without an outlet. Noassociations between proximity and lifetime number of quit attempts were detected

Table 2.3 (continued) Studies of local-level tobacco retail and smoking

Author	Objective	Study Population	Main Predictors	Main Outcomes	Design	Main Results
Halonen et al., 2014	To examine associations between the proximity to tobacco retail and number of stores and smoking cessation	Participants of the Finnish Public Sector study (1997-2005) (n=8751)	Tobacco retail residential proximity (straight-line and walking distance), number of stores within 500m from homes	Smoking cessation, smoking intensity	Longitudinal	Male moderate/heavy smokers living in closer proximity to tobacco retail were less likely to have ceased smoking. Presence of at least one store within 500m was associatied with a lower likelihood of cessation in moderate/heavy male smokers
Han et al., 2014	To examine the influence of tobacco outlet density and residential proximity to tobacco outlets on smoking cessation	who participated in an RCT in primary care assessing the impact of tailoring nicotine replacement therapy by genotype (n=633)	Residence-centered tobacco retail proximity and density using buffer sizes ranging from 250m to 3km	Smoking abstinence at six months	Longitudinal	No associations between residential proximity to tobacco outlets and sustained quitting at six months were detected
Marsh et al., 2015	density of tobacco outlets around secondary schools in New Zealand and current smoking, experimental smoking, susceptibility to smoking, and attempted and successful tobacco purchasing	New Zealand national survey of youth smoking (aged 14-15, n=27238)	Tobacco retail density	Smoking status, experimental smoking, susceptibility to future smoking, attempts/success to purchase tobacco	Cross-sectional	Current smokers were more likely to attempt to purchase tobacco in presence of a higher density of tobacco retail around their schools. Non-smoking students were more likely to be susceptible to smoking if the density of tobacco around their school was high. There was no significant association between density of tobacco outlets and successful purchasing, nor experimental smoking.
Marashi-Pour et al., 2015	To examine associations between density of tobacco outlets and neighbourhood socioeconomic status, as well as with individual smoking status	NSW, Australia Population Health Survey 2008–2010 (aged 16 , n=29375)	Tobacco outlet density per 1000 population	Smoking status	Cross-sectional	More disadvantaged areas were more likely to have higher tobacco outlet densities. In fully-adjusted models, neighbourhood-level tobacco outlet density was positively associated with individual smoking status
Shareck et al., 2015	To examine associations between tobacco retailer availability in residential neighbourhoods and in activity spaces, and smoking status	Montreal, Canada young adults (aged 18-25) (n=1994)	Tobacco retailer proximity and density around residential and activity spaces	Smoking status	Cross-sectional	Participants residing in areas with high numbers of tobacco outlets were more likely to be smokers, and so were those encountering medium and high retailer counts in their activity spaces. Participants with medium and high proximity to tobacco retail within activity spaces were more likely to be smokers. Residential proximity to tobacco outlets was not associated with smoking
Cantrell et al., 2015	proximity and density of tobacco outlets and cessation outcomes over time among nontreatment-seeking smokers, and to assess differences by neighbourhood poverty and individual factors	US cohort of adult smokers (aged 18–49, n=2377)	Distance to nearest tobacco store, tobacco retail density within 500m, 1km and 1.6km buffers	30-day abstinence, pro-cessation attitudes	Longitudinal	Smokers in high poverty areas living ≥500m from an outlet were more likely to be abstinent than those living <500 m from an outlet. Density within 500 m of home was associated with reduced abstinence and lower pro-cessation attitudes, but only in high poverty areas. In low poverty areas. Gender, education and heaviness of smoking did not moderate the impact of outlet proximity and density on cessation outcomes
Pearce et al., 2016	the neighbourhood tobacco retail environment and individual-level smoking and cessation, and whether inequalities in smoking status were related to tobacco retailing	Participants (aged 16) of 2008–2011 Scottish Health Surveys (n=28751)	Kernel density of tobacco retail using 400m, 800m, and 1000m radii	Smoking status, smoking cessation	Cross-sectional	Participants living in areas with the highest outlet densities were more likely to be current smokers, and less likely to be ex-smokers. There was little evidence of narrower smoking outcome inequalities in areas with lower availability of tobacco retailing
Cantrell et al., 2016	To examine the impact of neighbourhood tobacco retail outlet density on young adult initiation of different tobacco product types	US young adults (aged 18-34, n=4288)	Tract-level outlet density	Cigarette initiation in past 6mo, non-cigarette combustible initiation in past 6mo, initiation of any non-combustible products	Cross-sectional	Outlet density was associated with recent initiation of cigarettes and other combustibles. Higher outlet density wasassociated with a higher likelihood of initiating cigarette use among adults aged 25–34. No associations between outlet density and recent noncombustible product initiation were detected
Mennis et al., 2016	To examine associations between tobacco retail density and intention to smoke as a potential mediator of future smoking in urban adolescents	text messaging-based smoking cessation intervention among a sample of primarily African-American youth (n=187)	Residence-centered tobacco retail and density within half-mile buffers	Smoking intention	Cross-sectional	Tobacco retail density was associated with intention to smoke, which in turn predicted future smoking
Pulakka et al., 2016	To examine associations between changes in distance from home to tobacco outlet and changes in smoking behaviour	Adult participants of the Finnish Public Sector study and the Health and Social Support (HeSSup) study	Walking distance from home to the nearest tobacco outlet	Quitting smoking, smoking relapse	Longitudinal	Among baseline smokers, a 500m increase in distance from home to the nearest tobacco outlet was associated with an increase in odds of quitting smoking both in between-individual and within-individual analyses. No associations were detected between increases in distance to the nearest tobacco outlet and smoking relapse among ex-smokers
Chaiton et al., 2017	To explore the potential prospective impact of location and number of tobacco outlets on smoking cessation	Participants of the Ontario Tobacco Survey of adult smokers (aged 18 , n=2414)	Residence-centered tobacco retail proximity, threshold (1 outlet within 500 m) and density (outlets within 500 m)	Change in quit attempts, risk of relapse up to 3 years of observation	Longitudinal	Increased density of tobacco outlets was associated with lower odds of making a quit attempt, only in high-income neighbourhoods. Presence of at least one store within 500m was associated with an increased risk of relapse
Fleischer et al., 2018	To examine associations between point-of-sale (POS) display bans, tobacco retail density and tobacco retail proximity and smoking cessation and relapse	Participants of the International Tobacco Control Canada Survey, 2006-2011	Enactment of provincial POS display bans, tobacco retail density (# of stores with a 1km radius centered around residential addresses), closest tobacco outlet from residence	1 month cessation at follow-up, relapse at follow-up among smokers who had quit at the previous wave	Longitudinal	POS display bans were associated with lower odds of relapse. No associations between POS display bans and cessation were detected. Neither tobacco retail density nor proximity were associated with cessation or relapse

Also related to environmental features that may provide opportunities for smoking, the extent to which public areas facilitate smoking (*smoking accommodation facilities*) –e.g.: by allowing smoking in outdoor sections of bars and restaurants- and the *existence and enforcement of smoking laws and regulations* have been studied in relationship to smoking prevalence and quit attempts. Some of these studies suggest a reduction in smoking prevalence and/or number of cigarettes smoked following indoor smoking bans (151-153). Nonetheless, one study found no associations between these regulations and youth past-month smoking (154), and another reported a reduction in indoor smoking rates, but not in the total number of cigarettes smoked (155). Moreover, whereas some results may suggest an overall positive effect of indoor smoking bans, others indicate that in many cases, public spaces have been re-negotiated (156) re-configuring them to facilitate outdoor smoking, and therefore resulting in corresponding significant increases in outdoor smoking rates (153, 155). These smoker accommodation facilities, although not often studied, have been found to be associated with a lower likelihood of making a quit attempt and a higher likelihood of relapse (157), and with a higher likelihood of being a smoker for 2 years or longer (158). As for other environmental features thought to operate through policy and regulation pathways, a few studies examined the potential impact on smoking outcomes of *neighbourhood regeneration* initiatives seeking to improve dwelling conditions for disadvantaged groups. Results from this research, whereas perhaps suggesting a beneficial effect of these interventions on smoking (159), to date have shown inconsistent results (159-161). (See Table 2.4 below for details regarding studies of other local-level features operating through policy/regulation and smoking).

Table 2.4 Studies of other local-level features operating through policy/regulation and smoking

Author	Objective	Study Population	Main Predictors	Main Outcomes	Design	Main Results
Blackman et al., 2001	To assess the effects of neighbourhood renewal on residents' health (including smoking)	Participants of a survey in Newcastle-Upon-Tyne, UK following an urban renewal intervention	Neighbourhood renewal intervention	Smoking status	Longitudinal	Following the renewal work, smoking declined sharply
Trotter et al., 2002	To assess smokers' perceived effects of smoking bans in bars, nightclubs, and gaming venues on their smoking behaviour	Adult smokers (aged 18) residing in Victoria, Australia (n=597)	Exposure to smoking bans in bars, nightclubs, and gaming venues	Cued smoking, readiness to quit	Cross-sectional	The majority of participants reported smoking more in these settings. 25% indicated they would be likely to quit if smoking were banned in social venues. Compared to smokers not likely to quit if there were bans, smokers likely to quit were more likely to be socially cued, to be contemplating or preparing to quit, and to approve of bans in social venues
Klein et al., 2009	To examine associations between local clean indoor air policies and smoking behaviours among youth over time	Participants of the Minnesota Adolescent Community Cohort (aged 11-16 at baseline, n=4233)	Presence of local clean indoor air policies	Past-month smoking	Longitudinal	No significant associations between clean indoor air policies and youth smoking behaviours were detected
Ashley et al., 2011	To determine whether cigarettes were smoked more intensely outside of public venues in Scotland, compared to indoors, after introduction of a public place smoking ban	Regular smokers aged 21-64 who typically went to pubs, bars, clubs or restaurants at least twice a week	Enactment of a public place smoking ban	Numbers of cigarettes smoked indoors and outdoors, human-smoked yields of tar and nicotine	Longitudinal	Numbers of cigarettes smoked indoors in public places decreased significantly after the ban, with a corresponding rise in outdoor smoking incidence. No changes in total number of cigarettes smoked were detected. Human-smoked yields of tar and nicotine decreased slightly after the introduction of the ban
Kennedy et al., 2012	To examine smoking prevalence and behaviour and to assess levels of support for smoking restrictions in outdoor hospitality settings after the implementation of smoke-free legislation	Adult participants of the International Tobacco Control France Survey (aged 18 , n=1067 smokers, 414 non-smokers, 164 quitters)	Enactment of indoor smoking bans	Smoking behaviour at hospitality venues	Longitudinal	Reported outdoor smoking increased after enactiment of indoor smoking bans. Non-smoking visits to hospitality venues increased after the smoking ban. Most smokers and non-smokers supported partial or complete bans on smoking in outdoor areas of restaurants
Bond et al., 2013	To examine associations between experience of housing improvement in deprived areas and smoking outcomes	Participant of the GoWell study of housing improvement in deprived areas in Glasgow, UK (n=1062)	Experience of housing improvements	Smoking status, intention to quit	Longitudinal	Intention to quit smoking was positively associated with experience of housing improvements. No associations between smoking status and housing improvements were detected.
Pieroni et al., 2013	To examine the short-term effects of public smoking bans on individual smoking and drinking habits	Participants of the Italian Everyday Life Aspects survey	Enactment of public smoking bans	Smoking intensity, smoking prevalence	Longitudinal	Estimates of smoking prevalence and number of cigarettes smoked were not significantly different after the enactment of public smoking bans
Kearns and Mason, 2015	To examine associations between residential conditions and location status in deprived neighbourhoods and health behaviours (including smoking)	Glasgow, Scotland residents in different types of disadvantaged neighbourhoods	Internal and external dwelling quality, neighbourhood environment quality, local service and amenity quality, neighbourhood problems	Smoking status, change in smoking status, intention to quit, smoking in household	Cross-sectional	Compared to those remaining in regeneration areas, smoking outcomes were worse among those relocated elsewhere
Ghenadenik et al., 2016	To examine associations between presence of tobacco retail and presence of smoker accommodation and smoking trajectories over two years among young adults	Participants of the Montreal, Canada Interdisciplinary Study of Inequalities in Smoking (aged 18-25, n=2093)	Presence of tobacco retail and presence of smoker accommodation	2-year smoking trajectories	Cross-sectional	The likelihood of being a smoker for 2 years was greater among those living in larger spatial unit areas with greater presence of smoking accommodation. This association was not significant at smaller spatial units
Chaiton et al., 2016	To examine whether exposure to smoking on patios is associated with the likelihood of making a quit attempt and the risk of relapse after a quit attempt	Participants of the Ontario Tobacco Survey of adult smokers (aged 18 , n=3460)	Exposure to patio smoking	Changes in smoking behaviour (making a quit attempt, time to relapse after a quit attempt)	Longitudinal	Smokers exposed to smoking on patios (or having visited a patio) were less likely to have made a quit attempt. Smokers exposed to smoking on patios were more likely to relapse after making a quit attempt

The pertinence and relevance of studying the health-promoting and health-deterring potential of characteristics of physical environments has been repeatedly highlighted in the literature (5, 8, 162). Since strategies seeking to achieve "tobacco endgame" goals (e.g.: significant reductions in smoking prevalence including targets of 5% or lower by 2025 in Finland, Ireland, New Zealand and Sweden and by 2034-2035 in Canada and Scotland (77)), in particular those concerning environmental features, are heavily weighted towards factors operating through policy and regulation pathways (77, 163, 164), this dissertation is focused on these features. The next section will discuss the importance of examining residential environment features not only in terms of their association with smoking prevalence and other point-specific measures but also regarding their potential to influence smoking behaviour patterns.

2.4 The need for knowledge regarding the potential influence of environmental features on smoking behaviour patterns

As highlighted in the previous section, most studies of environmental features and smoking have examined initiation, prevalence and cessation of behaviours at discrete time points. This can be seen in the results of a 2015 systematic review of health-risk behaviours and neighbourhood deprivation: in this review all studies focused on tobacco use examined current smoking status as their outcome measure (165). This is also the case for most studies of neighbourhood features and smoking, as reported in other reviews (166-168).

Although this research is certainly valuable, it may only provide a partial understanding of environmental influences on smoking. That is, little may be gleaned in terms of the potential impact of environmental features on smoking behaviour patterns. This is an important limitation to advancing knowledge regarding potential determinants of smoking, as well as a hurdle to the development of effective interventions aiming to change smoking behaviour because as discussed in the introductory chapter, different smoking behaviour patterns may be influenced by distinct features. Hence, the potential influence of residential environment features on specific smoking patterns must be examined.

2.4.1 The emergent evidence of the potential influence of environmental features on specific smoking behaviour patterns

To date, most studies of environmental features and smoking behaviour patterns have been focused on adolescents and adults. These studies have preponderantly examined two specific features: the effects of exposure to point-of-sale (POS) marketing (i.e.: in-store advertising, pack displays, price promotions, other promotions), and the impact of legislation (i.e.: smoking bans) on smoking behaviour. Regarding POS marketing, there is consistent evidence of significant associations between this feature and smoking behaviour. A 2011 Cochrane review (169) found that adolescents who were non-smokers at baseline and were exposed to tobacco advertising (including POS marketing) were more likely to have experimented with cigarettes or become smokers at follow up. A more recent study (142) reported similar results, and associations were also found between presence of POS marketing and a lower likelihood of sustained smoking cessation (170, 171).

In contrast with studies of POS marketing, the evidence regarding the impact of smoking bans on smoking behaviour patterns appears to be inconsistent. On the one hand, an Italian study of health behaviour in individuals aged 20 to 60 years following a national indoor smoking ban in 2005 (152) found a significant 2-year reduction in the number of cigarettes smoked. Such decreases were also reported in qualitative studies in England (151) and Scotland (156). Conversely, a US-based study of smoking behaviour in adolescents following the enactment of "clean air" legislation (154) did not find any significant associations, whereas a Scottish study using an objective measure of tobacco consumption (filter analysis measurements that estimated human-smoked yields of tar and nicotine from cigarettes) (155) found no changes in smoking intensity following an indoor public-place smoking ban.

Aside from the two features described above, evidence showing associations between other environmental features and smoking behaviour patterns has begun to emerge in recent years. This is the case of *proximity and density of tobacco retail*. Regarding proximity, a Finnish study (139) reported a lower likelihood of sustained smoking cessation in moderate-to-heavy smokers (but not in light smokers) living in areas with at least one tobacco retail store within a 500m radius. In the same vein, a Canadian study (144) reported an increased risk of relapse within similarly-defined areas. However, associations between sustained cessation and proximity to tobacco retail stores within different radii varying from 250m to 3km were neither significant in a British study (146) nor in a recent Canadian study (149).

As for tobacco retail density and its association with sustained smoking cessation, an American study of differences by poverty level in adult smoking cessation (137) found that individuals residing in high poverty areas with a high density of tobacco retail within 500m of their homes were less likely to be abstinent. Also, the above-cited Canadian study (144) found lower odds of making a quit attempt, however in this case in high-income areas with a high tobacco retail density. Finally, other studies did not detect any significant associations between tobacco retail density and sustained cessation (145, 146, 149) or likelihood to relapse (149). Of note, only a few studies have examined associations between this feature and distinct smoking behaviour patterns. Nonetheless, results from two studies of initiation and maintenance of smoking among adolescents suggest that

proximity/density of tobacco retail may be relevant to smoking initiation but not to smoking maintenance (62, 63).

Even though research in this area is still emerging, these studies provide important information regarding the potential for residential environment features to influence distinct smoking behaviour patterns. Having said that, to date empirical findings tend to be inconsistent. As suggested in a 2007 scoping review of multilevel studies on small-area effects on health (172), several conceptual and methodological issues must be considered to adequately examine the potential influence of environmental features on health behaviour. Among these, the authors highlight the need for a clear definition of types, sizes and boundaries of spatial units of analysis, which should be coherent with how environmental features are thought to operate in terms of their potential effects on health behaviour.

Drawing from the health geography literature (64-66) I argue that the lack of sufficient consideration for spatial scale-related issues is one of the challenges that may be at the base of these inconclusive findings. The next section will discuss how spatial scale has been treated to date in place and health studies, the potential shortcomings arising from neglecting scale-related issues, and the approaches that may be used to address them.

2.5 Definition and measurement of environmental features in health behaviour studies

As mentioned in the introductory chapter, the definition and measurement of environmental features has long been a central issue in the field of health geography. Nonetheless, although being increasingly considered, this is still an under-researched area in epidemiological studies. For example, a 2016 systematic review of neighbourhood effects research in the US (24) noted that very few studies (3.9%) explicitly acknowledged potential limitations related to spatial scale, whereas Root (2012) highlighted that few of them have attempted to examine these issues empirically (173). Furthermore, studies seeking to document scale-dependent empirical variations of associations between environmental features and smoking behaviour are scarce. This is problematic given that relevant spatial definitions may differ depending on the features and outcomes being examined, as well as on the population of interest (68, 174-176). This is because spatial distributions of specific environmental features and health-related processes may take place

and operate at different scales (64). Therefore, the delimitation of spatial units must be as relevant as possible to specific sets of features and outcomes under study (67, 68, 177, 178).

There is however little agreement regarding what types of spatial units may be best suited to examine specific environmental features (67, 177, 179). This lack of agreement can be appreciated in the diverse spatial approaches that have been used to measure tobacco retail proximity and density. Some studies examining associations between residential presence of this feature and smoking outcomes used small areas such as 250m/500m/800m or 0.5/0.75-mile linear or road-network buffers around residences (100, 131, 134, 139, 144, 147) or mesh-blocks (census-based areas with an average population of 100 in New Zealand) (148). Other studies used slightly larger areas centered around residences such as 1km or 1-mile buffers (107, 131, 149) census tracts (census-based areas with an average population of 4000 in the United States) (98, 99, 133, 141) and adaptive kernel density buffers designed to capture 1000 residents (132). Finally others used areas encompassing an entire town/community (63), as well as different areas ranging from 250m to 3km buffers around residences (137, 145, 146) and outlet-centered areas (180).

Perhaps a reflection of the somewhat loose operationalization of local areas in the health and place literature (181) this heterogeneity may be one of the factors underlying differences in presence, size and direction of associations across empirical studies (178). This practice may lead to potential threats to validity arising from an inadequate consideration of spatial issues. For example, the choice of a spatial scale that does not correspond to the geographical level at which an exposure is hypothesized to influence health behaviours may translate into an inappropriate operationalization of geographical boundaries, which in turn may result in significant measurement error (182). This problem will be discussed in the next section.

2.5.1 The Modifiable Areal Unit Problem (MAUP)

A key source of measurement error related to differences in how spatial units are operationalized is the well-known "modifiable areal unit problem" (MAUP) (25). Because there are many ways to partition a specific territory into discrete units, in the presence of MAUP, estimates of between-area variation may depend on how boundaries are defined (183, 184) and may result in two types of error. The first, known as the *scale effect*, may arise due to the

aggregation of data from a specific set of areal units at different geographic levels (e.g.: data collected at the dissemination block level, which can be aggregated at the dissemination area, census tract, and so on). Depending on the aggregation level, analyses can give way to different answers to a specific question depending on the scale used. The second, termed *zoning effect*, may arise depending on how boundaries are defined using a similar geographic scale, and may also give different answers to a specific question (182, 184).

Contrasting findings among studies of residential environment features and smoking may be at least in part due to MAUP. For example, whereas a number of studies of smoking status and neighbourhood disorder (typically using zip code/postal code zones, which vary significantly in terms of area size, and also larger neighbourhood/area definitions) found significant associations (89-91, 185-188) others using smaller types of spatial units such as block faces (i.e.: a street segment between two intersections) (125), and participant-reported/perceived areas of varying sizes (124, 126) did not.

Different approaches may used to attempt to mitigate MAUP resulting from aggregation processes. These approaches can be either automated or subjective. Whereas automated algorithms seek to create areal systems that minimize intra-unit variance while maximizing inter-unit variance, heuristic subjective approaches that test associations using different spatial unit types are also deemed appropriate (189). Both may be effective in mitigating threats resulting from potential misclassification and underestimation of contextual effects on health. Nonetheless, the latter is a more common approach (190) especially in light of the relative scarcity of theories linking spatial scales, mediating processes and outcomes (11). Using sensitivity analyses based on different types of spatial units, heuristic approaches seek to identify areal definitions that maximize measures of association between environmental features and health indicators. Following recommendations by several scholars in this area (128-132), this thesis will address spatial scale uncertainties using a heuristic approach. That is, different types of territorial units will be examined to test the presence and strength of associations between residential environment features and smoking behaviour patterns. Of note, aggregation-related issues may be avoided using other approaches, notably Bayesian statistical methodologies (191), however they will not be discussed in the context of this thesis.

2.5.2 The conundrum of identifying pertinent spatial units[1]

Further to MAUP mitigation, another important consideration that concerns place-effects studies is related to the identification of pertinent spatial units. The definition of relevant exposure areas is a central issue for the long-standing debate regarding what constitutes a pertinent unit of analysis. From a conceptual standpoint, whenever possible, the choice of spatial scales should be guided by theory. To guide hypotheses regarding the spatial scales at which processes underlying associations between smoking behaviour patterns and residential environment features operate, this dissertation used Bernard et al.'s (2007) conceptual framework (10). This framework proposes that local areas help shape health outcomes through differential distributions of resources, which can be categorized within five domains (physical, economic, institutional, local sociability, community organizations) governed by four types of rules (proximity, price, rights, and informal reciprocity).

Specific to the features examined in this dissertation, the physical domain, which is composed of elements of the natural and built environments at the residential level is proposed to be regulated by the rule of proximity. Therefore, residents of a particular area may have access and be exposed to these resources by virtue of their geographic proximity. Although strictly falling within the economic domain and hence regulated by rules of market and price (which shape the quality and quantity of resources that may be accessed by neighbourhood residents), as suggested by the results of multiple studies, the local *presence/density of tobacco retail stores* may be also conceptualized as a resource operating through proximity mechanisms.

Different to the physical domain, the institutional domain is proposed to regulate access to resources via citizen's rights enacted by public rules (e.g.: regulations regarding indoor/outdoor smoking), above and beyond their proximity to residents. Since the exposure to *smoking in outdoor spaces and other smoking accommodation facilities* may be shaped by regional-level differences in regulations and their enforcement, mechanisms underlying associations between this feature and smoking behaviour can be hypothesized to operate at a larger spatial scale.

[1] As proposed by Gauvin et al. in Gauvin L, Robitaille E, Riva M, McLaren L, Dassa C, Potvin L. Conceptualizing and Operationalizing Neighbourhoods: The Conundrum of Identifying Territorial Units. Can J Public Health. 2007;98(S1):S18-S26.147.

2.5.3 Different approaches used to define spatial units in studies of contextual effects on health

In addition to spatial scale considerations, health and place studies must choose between a variety of methodological approaches concerning the definition of local geographical units. Spatial units can be classified based on a variety of criteria. In general terms, areas may be delimited based on either subjective or objective approaches. Subjective approaches are intended to reflect how individuals conceptualize and perceive their environments. By tapping into the cognitive dimension of place, individuals are allowed to make their own spatial representations of what constitutes their environment, which may be different to those of their neighbours (192, 193). Within these methodologies, participants are asked to identify what they believe the boundaries of their residential and/or other environments are, either on maps, or by direct field observation. These approaches are relevant to different types of research questions (e.g.: to capture variability in individual-level accessibility to neighbourhood-level resources based on subjective perceptions of neighbourhood boundaries). Some scholars have nonetheless criticized them, arguing that perceived boundaries may not be reflective of "true" environmental exposure areas (194, 195).

Objective approaches leave the task of defining spatial units to the researcher. These areas can be "ego-centric/sliding" or "territorial/fixed" (181, 194). Ego-centric units, as their name suggests, are constructed from the individual's standpoint, and emphasize the importance of capturing the local environmental conditions to which a person is exposed. Examples of ego-centric spatial units are circular buffers with various radii centered around individual residential addresses (e.g.: 500m, 1km, etc.) and street network buffers. Territorial units, on the other hand, attempt to capture socially-consistent entities that are independent of individuals (196), focusing on group-level characteristics of places that may exert a positive or a negative effect on health (197). Census-based and administrative units (e.g.: census tracts, dissemination areas, health service areas) are typical examples of territorial units. Although these are the most common types of areas used in health and place research, more complex approaches can be used to define territorial units, notably to reflect the different factors that may influence their boundaries, including 1) the historically constructed meaning of the area, 2) homogeneity of socio-economic characteristics of residents, 3) presence of natural physical boundaries, 4) the subjective perception of neighbourhood by residents, 5) the presence of social networks, and 6) population size thresholds (174, 198, 199).

2.5.4 Can administrative units be relevant to study contextual effects on health?

The use of census-based and administrative units has received considerable criticism from several scholars. Critics typically voice concerns regarding 1) the "arbitrary" nature of their boundaries (e.g.: 65, 181, 200), 2) differences between these units and individual perceptions of neighbourhoods (e.g.: 201) as well as 3) potential inter-individual differences in unit sizes (e.g.: 202), and 4) the need to consider spatial units beyond residential neighbourhoods as potential individual exposure areas (e.g.: 203, 204).

Even though in general terms these critiques are pertinent, as suggested above, the suitability of a specific spatial approach will depend on the specific research question and hypothesized mechanisms of action. Furthermore, it is important to highlight that despite these criticisms, administrative units are not necessarily arbitrary. For example, Canadian and US census tract boundaries (in Canada representing local areas with populations of less than 10,000 (205)) are typically *"[…] drawn in consultation with local communities to reflect important physical features and social and ethnic divisions"* (206). Moreover, even though their boundaries are fixed and their use is often centered around residential addresses as proxies for areas of exposure (and acknowledging the importance of other areas that comprise daily activity spaces (136, 150)), they can often constitute reasonable measures of spatially-constrained individual and collective actions and interactions, since *"[…] where [persons live]…generally affects their exposure to different sets of norms and institutions"* (197), as well as for their accessibility to opportunity structures that include resources such as tobacco retail stores, parks and other recreation areas, and hospitals and other healthcare organizations.

2.6 Objectives and expected contributions of this thesis

As stated in the introductory chapter, the overarching aim of this thesis is to advance knowledge regarding smoking behaviour patterns among young adults and their associations with residential environment features, with special attention to the scales at which these associations may be best observed and understood. The volatile nature of tobacco use in this population renders this case particularly well-suited to examine associations between residential environment features and smoking behaviour patterns and may also point to their potential influence on smoking behaviour in other populations.

Effective public health policy and intervention seeking to curb smoking in young adults requires a better understanding of determinants of smoking behaviour patterns. In this regard, the main contribution of this thesis is twofold: it provides empirical evidence regarding different smoking behaviour patterns among young adults, as well as information regarding the potential influence of residential environment factors on these patterns. This knowledge will in turn help inform public health interventions regarding the most appropriate targets for tobacco control efforts seeking to curb smoking among young adults.

This thesis sought to answer the following research questions: 1) can smoking behaviour in young adults be better described and conceptualized by examining smoking behaviour patterns over time, beyond point-specific smoking outcomes? 2) are specific residential environment factors associated with different smoking behaviour patterns? and 3) does the presence and strength of these associations vary at different spatial scales?

2.7 Research Hypotheses

The following hypotheses were formulated:

Article 1

H1.1: young adults living in neighborhoods with a greater presence of tobacco retail outlets and/or a greater presence of smoking accommodation facilities are more likely to change their status from non-smoker to smoker over two years

H1.2: young adults living in neighborhoods with a greater presence of tobacco retail outlets and/or a greater presence of smoking accommodation facilities are more likely to maintain their smoker status over two years

H1.3: young adults living in neighborhoods with a greater presence of tobacco retail outlets and/or a greater presence of smoking accommodation facilities are less likely to change their smoking status from smoker to non-smoker over two years

H1.4: young adults living in neighborhoods with a greater presence of tobacco retail outlets and/or a greater presence of smoking accommodation facilities are less likely to maintain their non-smoker status over two years

Article 2

H2.1: associations between tobacco retail presence, tobacco retail density and smoking behaviour patterns are stronger at a more local scale

H2.2: associations presence of smoker accommodation facilities and smoking behaviour patterns are stronger at a more distal scale

Article 3

H3.1: young adults residing in areas with presence of and/or a higher density of tobacco retail are more likely to have changed their smoking status at least twice over the course of 4 years

H3.2: young adults residing in areas with presence of and/or a higher density of tobacco retail are more likely to be persistent smokers

H3.3: young adults residing in areas with presence of smoker accommodation facilities are more likely to be persistent smokers

CHAPTER 3: METHODS

3.1 Introduction

This dissertation relied on data stemming from the *Interdisciplinary Study of Inequalities in Smoking* (ISIS) (CIHR grant MOP-110977) a cohort study conceived to advance knowledge of the joint role of individual and neighbourhood factors in the production of social inequalities in smoking among young adults living in Montreal. Nonetheless, this work is distinct from the ISIS project in that it involved the creation and examination of a new dependent variable, smoking behaviour patterns, and the thesis is focused on these patterns in young adults and how these may be influenced by residential environment features, acknowledging potential scale-related differences in associations.

3.2 Study design, population and sampling

The analyses for Article 1 were based on a retrospective measure of smoking behaviour, whereas the analyses for Articles 2 and 3 were based on prospective measures. The ISIS cohort was the main source of data for this dissertation. This cohort was recruited based on an initial list of 6,020 randomly-selected non-institutionalized young adults, aged 18 to 25 years at the time of contact. This list was provided by the *Régie de l'Assurance Maladie du Québec* (RAMQ), Quebec's universal and publicly funded health insurance programme. Potential participants were required to have resided at the same address for at least one year and be proficient in either French or English to be eligible for inclusion. A two-level sampling frame was used: for each of the 35 local health and social services areas (CLSC)[1] on the Island of Montreal, a random list of 86 women and 86 men was provided for initial contact. This list included the name, sex, date of birth and residential addresses of potential participants.

A letter of invitation was sent to the initial list, and up to two follow-up reminder letters were sent and telephone calls were made to potential participants. Residential addresses for each of the 6,020 individuals from the initial list were geocoded and classified according to the dissemination areas of residence's material deprivation quartile. Dissemination areas are the smallest administrative units used for census purposes by Statistics Canada (207). Area-level material

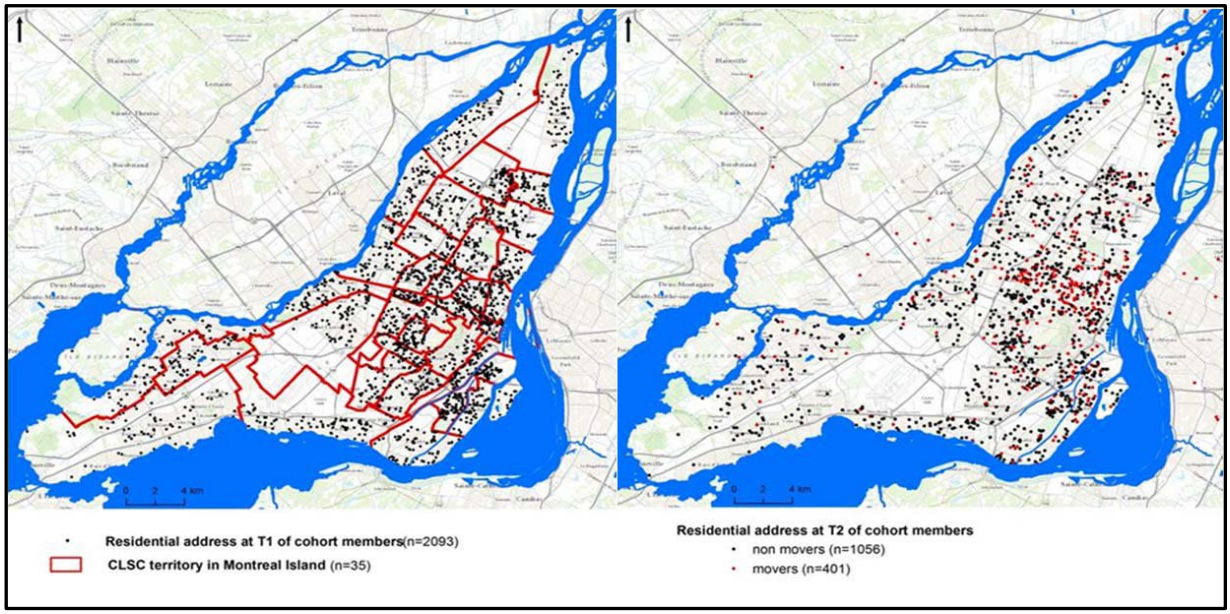
[1] CLSC territories are administrative units based on the provision of health and social services created by the Ministry of Health and Social Services. There were 35 CLSC territories on the Island of Montreal at the time of recruitment of the ISIS cohort.

deprivation quartiles were measured using the Pampalon Index (208), a socio-economic indicator widely used in the province of Quebec. This index is a validated composite measure (209) that has been found to be associated with a variety of health outcomes including tobacco-related mortality (210). It combines three indicators: income, education (proportion of persons aged 15 years or older who do not have a high-school diploma) and work status (ratio of employment to population 15+ years). This information was used to inform recruitment and recall strategies, notably to attempt to include individuals residing in areas representative of all levels of material deprivation.

Upon acceptance and verbal or written informed consent (see Appendix I), individuals were invited to complete an online baseline questionnaire. Other response methods were made available upon request, including mail-response, telephone and in-person interviews. A CAD$10 gift certificate redeemable at three selected bookstores and music stores was offered as financial compensation for participation. The ISIS study obtained ethical approval from the Research Ethics Committee of the Université de Montréal's Faculty of Medicine (certificate #11-019-CERFM-D). Ethical approval for this doctoral research thesis was obtained from the Health Research Ethics Committee of the Université de Montréal (certificate #15-055-CERES-D – see Appendix II).

Data collection for the baseline individual questionnaire took place between October 2011 and August 2012. Upon exclusion of 458 ineligible individuals, a total of 2,093 individuals completed the baseline questionnaire, for a final response rate of 37.6%. Even though somewhat low, these rates are in line with expectations in observational studies. A follow-up individual questionnaire was completed two years later. Participation was solicited via letter invitations, followed by e-mail, telephone and mail reminders. Almost three quarters of the baseline sample (73.3%) completed a follow-up questionnaire, for a total of 1,457 participants. Responders and non-responders at follow up were similar in terms of age, physical health and neighbourhood deprivation level. Nonetheless, non-responders at follow-up were more likely to be male, less educated, to be smokers, and to report excellent or fair/poor self-rated mental health. Full sampling and survey details are available elsewhere (211). The geographic distribution of participants at baseline (T1) and follow-up (T2) can be found in Figure 3.1 below. Details concerning the number of participants by time of survey and reasons for inclusion/exclusion from the analytical samples used in this dissertation can be found in Appendix III.

Figure 3.1. Residential addresses of ISIS participants at baseline and follow-up (2011-2012, 2014)

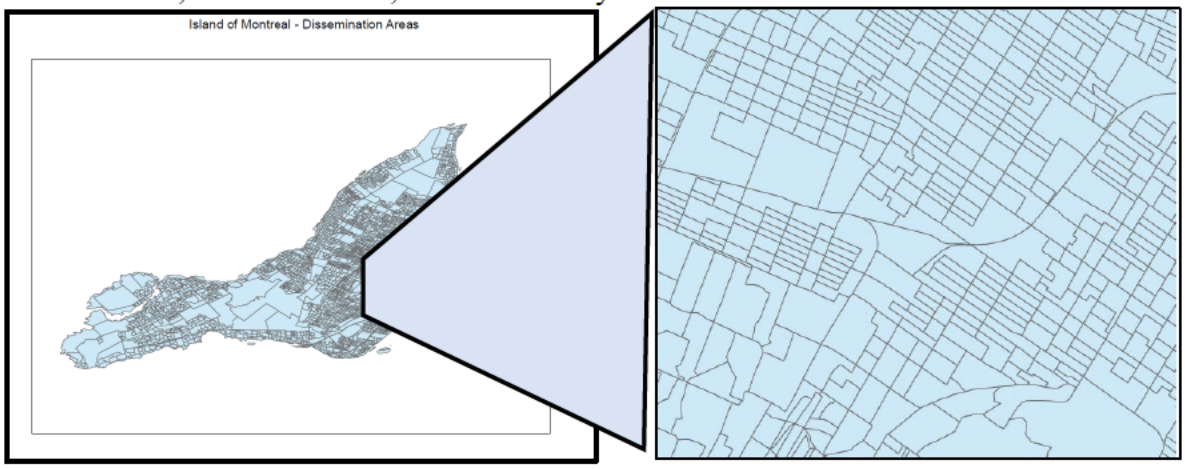


Source: Interdisciplinary Study of Inequalities in Smoking, 2015

3.3 Operationalization of spatial scales used in this thesis

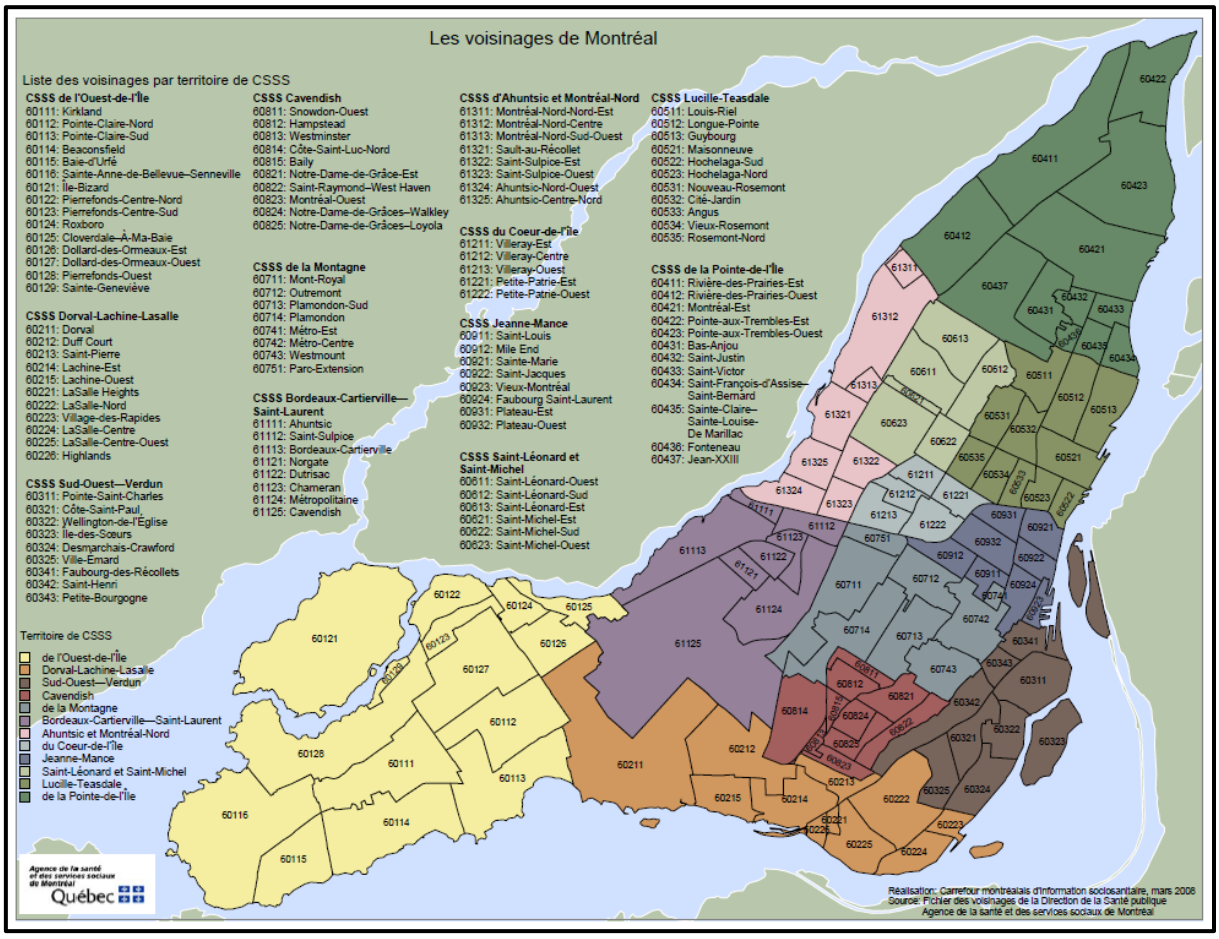
Three nested, increasingly larger spatial scale types were examined in this thesis. The smallest units were dissemination areas (DAs), which were used as proxies for residential proximity, to capture residential environment features within walking-distance proximity to individual addresses of residence. As mentioned in the previous section, dissemination areas are the smallest census-based units in Canada. There are 3175 DAs on the Island of Montreal. Each DA has between 400 and 700 residents, and their mean area is 0.16 km^2. DA areas can be roughly equated to 500-meter circular or road-network buffers. The latter is a typical measure used in health and place studies (136, 144), corresponding to a 5-minute walk at average pace speed. Their boundaries can be seen in Figure 3.2 below.

Figure 3.2. Dissemination Areas on the Island of Montreal / Close-Up Plateau-Mont-Royal, Petite-Italie, Parc-Extension, Ville Mont-Royal



The second scale used to examine associations between residential environment features and smoking behaviour patterns was the neighbourhood level, operationalized using Montreal's *"voisinages"* or *"sociological neighbourhoods"* (SNs). These are community-defined spatial units, created in collaboration between Montreal's *Direction de Santé Publique* (DSP) and local community organizations. The objective of SNs is to represent, as close as possible, neighbourhoods in terms of the shared perceptions of their residents regarding their history, sense of belonging, infrastructure and services, and population characteristics. There are 111 SNs on the Island of Montreal (212). Their mean area is 4.5 km^2, and their mean population in 2011 was 17,000 residents. Since their inception, SNs have been used as relevant spatial units for local-level public health initiatives. Figure 3.3 shows the 111 SN territories on the Island of Montreal.

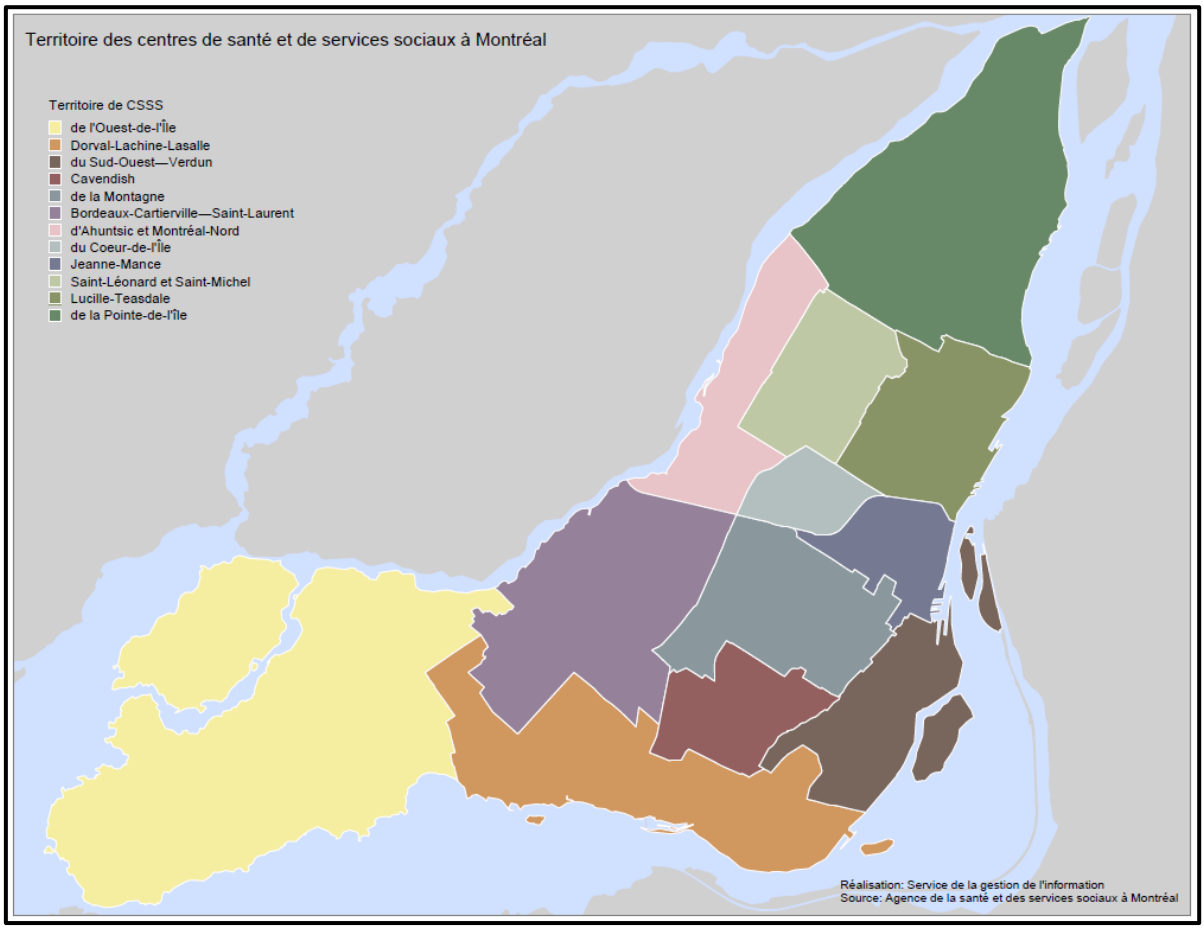
Figure 3.3. Sociological Neighbourhoods on the Island of Montreal



Source: Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal, 2018

Finally, a third scale seeking to examine residential environment features at a more regional level was used. These larger spatial units were operationalized based on *Centre de santé et de services sociaux* areas (CSSSs, Health and Social Services Centre Areas). Before the reorganization of health and social services that took place in 2015 (213), CSSS were administrative units used for planning and delivery of health and social services (214). These units encompassed service organizations such as hospitals, youth services centres and rehabilitation centres, health practitioners, pharmacies, private and community organizations, and multi-sectoral organizations. There were 12 CSSS territories on the Island of Montreal at the time of data collection. Their mean area was 41.7 km^2, and their mean population in 2011 was 157,210. Figure 3.4 shows the 12 CSSS territories on the Island of Montreal.

Figure 3.4. Health and Social Services Centres on the Island of Montreal



Source: Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal, 2018

3.4 Residential environment features

Three residential environment features were examined in this thesis: presence of tobacco retail stores, density of tobacco retail stores, and presence of smoker accommodation facilities. To mitigate potential bias arising from participants migrating to areas with varying levels of exposure, all analyses for Articles 2 and 3 were restricted to individuals residing at the same spatial unit both at baseline and follow-up. For Article 1, this issue was mitigated by the requirement of residence at the same address for at least 1 year prior to baseline.

Measures for presence and density of tobacco retail stores were extracted from the MEGAPHONE (Montreal Epidemiological and Geographical Analysis of Population Health Outcomes and Neighbourhood Effects) database. This is a geographic information system that

seeks to characterize social, built and physical environmental factors to understand the relationship between contextual and compositional factors and health outcomes in the Montréal region (215). Developed with the support of the Canada Foundation for Innovation, MEGAPHONE has a fully relational structure that integrates a geo-database and comprehensive series of datasets including over 800 variables representing physical, built and social environment factors, including land use, satellite images, transportation systems, location of institutions, services and businesses, crime data, Census data, mobility data and direct observation data. Data is coded at the census tract and DA levels.

Data used to characterize the tobacco retail residential environment stemmed from the 2011 DMTI Enhanced Points of Interest (EPOI©) database (216). This is a source that provides geocoded address points for different land uses including tobacco-selling stores. The EPOI© database classifies commercial outlets based on Standard Industrial Classification codes, which indicate their business activity sector. Outlets which could legally sell tobacco products in the province of Quebec at the time of data collection included convenience stores, gas stations, grocery stores, and specialized tobacco stores. This source's validity was assessed using the 2010 version of the EPOI© database. Based on a novel measure of *representativity*, which tolerates mismatches in business names or slight but immaterial imprecisions in location, sensitivity values were 0.75 for convenience stores and 0.92 for supermarkets whereas positive predictive values were 0.75 and 1.00 for each store type respectively.(217). The number of stores that were legally allowed to sell tobacco products was obtained and spatialized in ArcGIS© v.10.4 at the DA level. Density of tobacco retail was calculated by dividing store counts per DA by the area of the DA in km^2. Mean values for spatial units larger than DAs (SNs and CSSSs) were computed.

Both presence and density of tobacco retail were operationalized as dichotomous variables. DAs with presence of at least one tobacco retail outlet were coded "1" whereas DAs with no presence of this feature were coded "0". DAs at which the highest densities of tobacco retail were observed (those in the highest quartile) were coded "1" whereas all other DAs were coded "0". A similar approach was used for SNs and CSSSs: units with mean presence levels or densities in the highest quartile were coded "1" whereas all other units were coded "0".

Presence of smoker accommodation facilities was measured based on the ISIS observational database. This database includes 86 theoretically-informed indicators of presence and quality of different residential environment features, selected based on Bernard and colleagues' theoretical framework (10), and measured using a validated observation grid (See Appendix IV). A validation study of this instrument showed that approximately 75% of indicators were measured with acceptable to excellent reliability (218). Collection was performed by trained observers between June and September 2012. Observations were conducted at the street section level. Street sections were defined as street segments between two intersections measuring more than 60 metres in length. A total of 1,399 sections around participants' residential addresses and representing unique dissemination areas were audited. Street sections with presence of at least one of four smoking accommodation features (ashtrays or designed areas at the entrance of retail stores, institutions, and community organizations, or in terraces/patios in bars and restaurants) were coded "1", whereas sections with no presence of any of these features were coded "0".

Mean values for spatial units larger than DAs (SNs and CSSSs) were computed. Then, to be able to contrast units with the highest values to all other spatial units, mean values at each of these scales were recoded into dichotomous variables. Units with values in the highest quartile were coded "1" to reflect higher presence or density of features, whereas all other units were coded "0" to reflect lower presence or density.

3.5 Outcome measures

Smoking behaviour patterns were measured based on responses to the baseline and follow-up ISIS individual survey questions. The baseline questionnaire was comprised of 98 questions (see Appendix V), whereas the follow-up questionnaire was comprised of 114 questions (see Appendix VI). Content validity was assessed by a panel of experts in public health, sociology, geography and tobacco control. Face validity was tested among young adults of different levels of education prior to baseline data collection.

Outcome measure for Article 1

For Article 1, a four-category retrospective measure of smoking behaviour patterns was constructed. These categories were defined using two measures: self-reported smoking status at

baseline (T1), measured in 2011, and self-reported prior smoking behaviour over a two-year period (T0). The two-year reference point used to measure prior smoking behaviour was based on evidence from studies of milestones of nicotine dependence and smoking cessation (81, 219-221). Responses to the following questions were used to categorize participants: 1) *Have you ever smoked an entire cigarette?* 2) *How old were you when you smoked an entire cigarette for the first time?* 3) *Currently, do you smoke cigarettes every day, occasionally, or never?* and 4) *When was the last time you smoked a cigarette?* Smoker status was operationalized using Health Canada's Canadian Tobacco, Alcohol and Drugs Survey (CTADS) definition, which considers both those who consume tobacco products occasionally or daily to be current smokers (222).

Participants who had never smoked an entire cigarette or reported a non-smoker status at baseline and smoking a cigarette for the last time at least 2 years ago were categorized as *non-smokers for 2 years or longer*. Participants who reported an occasional or regular smoker status at baseline and smoking an entire cigarette for the first time at least 2 years ago were categorized as *smokers for 2 years or longer*. Participants who reported an occasional or regular smoker status at baseline and smoking an entire cigarette for the first time less than 2 years ago were categorized as *smokers for fewer than 2 years*. Finally, participants who reported a non-smoker status at baseline and smoking a cigarette for the last time less than 2 years ago were categorized as *non-smokers for fewer than 2 years*. Details regarding this variable are shown in Table 3.1 below.

Table 3.1. Retrospective smoking behaviour pattern categories

T0 Smoking Status	T1 Smoking Status	Smoking Behaviour Pattern (Retrospective)
Non-smoker	Non-smoker	Non-Smoker ≥ 2 years
Smoker	Smoker	Smoker ≥ 2 years
Non-smoker	Smoker	Smoker < 2 years
Smoker	Non-smoker	Non-Smoker < 2 years

Outcome measure for Article 2

For Article 2, a four-category prospective measure of smoking behaviour patterns was constructed. To this end, baseline (T1) and follow-up two years later (T2) responses the ISIS

individual question *"Currently, do you smoke cigarettes every day, occasionally, or never?"* were used.

Participants who reported a non-smoker status both at T1 and T2 were categorized as *non-smokers for 2 years or longer*. Participants who reported a non-smoker status at T1 and a smoker status at T2 were categorized as *smokers for fewer than 2 years*. Participants who a reported smoker status at T1 and a non-smoker status at T2 were categorized as *non-smokers for fewer than 2 years*. Finally, participants who reported a smoker status both at T1 and T2 were categorized as *smokers for 2 years or longer*. Details regarding this variable are shown in Table 3.2 below.

Table 3.2. Prospective smoking behaviour pattern categories

T1 Smoking Status	T2 Smoking Status	Smoking Behaviour Pattern (Prospective)
Non-smoker	Non-smoker	Non-Smoker ≥ 2 years
Smoker	Smoker	Smoker ≥ 2 years
Non-smoker	Smoker	Smoker < 2 years
Smoker	Non-smoker	Non-Smoker < 2 years

Outcome measure for Article 3

For Article 3, a five-category 4-year smoking behaviour pattern variable was created, using the T0 (two years prior to baseline), T1 (baseline) and T2 (follow-up) measures.

Participants who had reported a smoker status at all time points were classified as *persistent smokers*.

Participants who were either 1) smokers prior to baseline (T0) and non-smokers both at baseline (T1) and follow-up (T2) or 2) non-smokers for fewer than two years at baseline (smokers at T1 but non-smokers at T0) and were non-smokers at follow-up (T2) were classified as *ex-smokers*.

Participants who were either 1) smokers for fewer than 2 years at baseline (non-smoker at T0, smoker at T1) and were smokers at follow-up (T2) or 2) non-smokers for 2 years or longer at

baseline (non-smokers at T0 and T1) but were smokers at follow-up (T2) were classified as *new smokers*.

Participants who had changed their smoker status (either from smoker to non-smoker or vice versa) both at baseline (T1) and follow-up (T2) were classified as *switchers*.

Finally, those who were non-smokers at any time point were classified as *never smokers*. Details regarding this variable are shown in Table 3.3 below.

Table 3.3. 4-year smoking behaviour pattern categories

T0 Smoking Status	T1 Smoking Status	T2 Smoking Status	4-year Smoking Behaviour Pattern
Smoker	Smoker	Smoker	Persistent Smoker
Smoker	Non-Smoker	Non-Smoker	Ex-Smoker
Smoker	Smoker	Non-Smoker	
Non-Smoker	Smoker	Smoker	New Smoker
Non-Smoker	Non-Smoker	Smoker	
Smoker	Non-Smoker	Smoker	Switcher
Non-Smoker	Smoker	Non-Smoker	
Non-Smoker	Non-Smoker	Non-Smoker	Never Smoker

3.6 Covariates

Models for the three articles in this dissertation included three individual-level covariates: age, sex, and educational attainment. Article 2 also included a fourth individual-level covariate, daily smoking at baseline (details regarding this variable can be found in the article).

Age and sex: participants' date of birth and sex were retrieved from the list of potential participants provided by the RAMQ. Date of birth was also included for validation purposes in the individual questionnaires. Details regarding the operationalization of these variables can be found in each of the articles.

Educational attainment was used as a proxy for individual-level socioeconomic status (SES). Whereas other indicators have been used to document socioeconomic differences in young adults

(e.g.: employment status, income, and parental education), educational attainment is typically deemed as the most appropriate SES indicator for this age group, at least in developed countries (223-225). This is because it is thought to capture a variety of mechanisms through which SES may influence health in young adults, including health-related knowledge, values, skills and preferences, future employment and financial resources, and psychosocial resources (53, 226).

Educational attainment, measured at baseline, was operationalized as a dichotomous variable in all models. To this end, for participants who were not enrolled in studies at the time of survey, educational attainment was defined as the highest level completed, whereas for those who were this variable was defined as the level of studies being pursued at the time. In cases where the diploma obtained was higher than the educational level taught at the establishment which participants were enrolled in, the highest level was used. Thirteen options ranging from "no school, or only kindergarten" to "earned doctorate" were available to respondents. Participants who had already obtained a post-secondary diploma or were enrolled in post-secondary studies at baseline were coded "1", whereas those who completed high school or had a lower degree and were not enrolled in post-secondary studies at baseline were coded "0".

Fully-adjusted models also included *area-level material deprivation* as a covariate. This variable was operationalized using the Pampalon material deprivation index described previously in this chapter, measured at the DA level, and aggregated at each of the spatial scales. Spatial units with index scores in the highest material deprivation quartile were categorized as "most deprived", and coded "1". All other areas were coded "0". In Article 2, area-level material deprivation was operationalized as a continuous variable.

3.7 Statistical Analyses

A summary of the general analytical approach used in this dissertation is provided below. Detailed information can be found in each of the three articles of this thesis.

As a prelude to modelling, data was cleaned and checked for inconsistencies. Then, descriptive analyses were performed for all independent and dependent variables. Correlations between residential environment features were analyzed using Pearson correlation coefficients.

Associations between residential environment features and outcome variables were tested using multinomial multilevel random-effects models. This modeling approach is widely used in area-level effects studies, among other reasons because of its ability to: 1) account for correlated or clustered observations, and 2) describe the variability and heterogeneity in the population above and beyond average relationships (227).

A "step-up" approach to modelling was used, as described by Tabachnick and Fidell (228). This strategy progressively specifies increasingly complex multilevel models. The first step was to build intercepts-only or "null" models, with no independent variables specified at any level. Plausible value ranges (229) were computed to describe the extent of between-neighbourhood variability in smoking outcomes. Then, models using individual-level variables as predictors were constructed, including age, sex and educational attainment as predictors. Following this step, univariate models using each of the residential environment features at each spatial scale as unique predictors were constructed. Finally, fully-adjusted random-intercept models using the residential environmental features found to be significantly associated with smoking outcomes in the previous step as predictors, and all individual-level variables as well as area-level material deprivation as covariates were tested. No weights were applied. Analyses were conducted using SPSS v24/v25, and HLM v.7 software, which allows for continuous, count, ordinal, and nominal outcome variables to be built into linear and non-linear models based on hierarchically-structured datasets. Model equation details can be found in Appendix VII.

CHAPTER 4: RESULTS

ARTICLE 1

Title: Beyond Smoking Prevalence: Exploring the Variability of Associations between Neighborhood Exposures across Two Nested Spatial Units and Two-Year Smoking Trajectory among Young Adults

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ABSTRACT

Young adults have the highest prevalence of smoking amongst all age groups. Significant uptake occurs after high school age. Although neighborhood exposures have been found to be associated with smoking behavior, research on neighborhood exposures and the smoking trajectories among young adults, and on the role of geographic scale in shaping findings, is scarce. We examined associations between neighborhood exposures across two nested, increasingly large spatial units and smoking trajectory over two years among young adults living in Montreal, Canada. A sample of 2093 participants aged 18–25 years from the Interdisciplinary Study of Inequalities in Smoking (ISIS) was surveyed. The dependent variable was self-reported smoking trajectory over the course of two years. Residential addresses, data on presence of tobacco retail outlets, and the presence of smoking accommodation facilities were coded and linked to spatial units. Three-level multinomial models were used to examine associations. The likelihood of being a smoker for 2+ years was significantly greater among those living in larger spatial unit neighborhoods that had a greater presence of smoking accommodation. This association was not statistically significant at the smaller spatial units. Our findings highlight the importance of studying young adults' smoking trajectories in addition to static smoking outcomes and point to the relevance of considering spatial scale in studies of neighborhoods and smoking.

Keywords: neighborhood exposures; smoking trajectory; young adults; spatial scale; multilevel

1. INTRODUCTION

Smoking continues to be an unacceptable burden on the health of Canadians. Mortality caused by tobacco-related disease accounts for approximately 37,000 annual deaths in this country [1]. Tobacco use is thus the leading cause of preventable premature mortality [2]. This is of particular concern among young adults, who have the highest prevalence of smoking of all age groups: In 2012, prevalence in the 20–24 year and 25–34 year age groups was 17.9% and 18.5% respectively, compared to a prevalence of 14.6% in the general population [2].

Young adults not only have the highest prevalence, but they also experience significant changes in smoking behavior, both in terms of initiation and quit attempts [3–5]. Empirical studies provide evidence of significant smoking uptake in this age group, finding that as many as 25% of youth who took up smoking did so before age 24, but after high school age [3,4,6,7]. Moreover, the number of young adult smoking initiates appears to be surpassing that of adolescents, as suggested in a systematic review of smoking initiation in the United States and Canada [8]. These trends call for attention because young adulthood is recognized as a key transitional period in terms of health behaviors and risk factors, not only by public health organizations [9] but also by the tobacco industry, who identifies it as an important window to market tobacco products [10]. Nonetheless, this age group is frequently overlooked in tobacco control efforts [4] and underutilize evidence-based cessation treatments [11]. This, in spite of studies suggesting that successful prevention of smoking initiation during young adulthood increases the likelihood of never becoming a regular smoker [5].

Similar to other health outcomes, there are significant place-based inequalities in smoking [12–28]. For example, on the Island of Montreal, smoking rates differ significantly across place of residence; in 2007–2010, they ranged from 15.6% to 36.0% across the region's Health and Social Services administrative units [29]. These studies highlight the potential role of neighborhood-level factors as enablers and barriers to health, above and beyond individual-level socio-demographic characteristics such as age, sex and education, well known correlates of smoking [30]. Differences in health behaviors and outcomes at the neighborhood level are thought to arise in part due to differential distributions of resources available to their residents [31], as well as their differential capability to access them [32]. These resources may be health-promoting (e.g., greater levels of

neighborhood trust can be a protective factor for smoking behavior) [33] or health-deterring (e.g., a greater presence of tobacco retail stores may be associated with higher smoking rates) [34].

Acknowledging the importance of understanding the potential role of neighborhood exposures in shaping smoking behavior, there is a significant body of research devoted to the examination of associations between neighborhood-level exposures and smoking. Among an array of environmental exposures potentially associated with smoking outcomes, proximity and density of tobacco retail stores and presence of smoking accommodation facilities are thought to be relevant. A considerable amount of research has explored associations between smoking outcomes and proximity and density of tobacco retail stores. In adult populations, a greater density of tobacco outlets around address of residence has been found to be associated with a higher likelihood of smoking [14,35] and a lower likelihood of smoking cessation [36,37]. Among adolescents, proximity and a greater density of tobacco outlets around schools and homes have been found to be associated with higher experimental smoking rates [38], the number of cigarettes smoked daily [14,39], and likelihood of smoking [40]. However, while associations between exposure to tobacco retail and smoking outcomes have been explored in adolescents and adult populations, very few studies have examined the potential impact of proximity and density of tobacco retail stores on smoking outcomes in young adults. A recent study found a positive association between density of tobacco outlets and smoking initiation in individuals aged 18–34 years [41]. Another recent study included both residential neighborhoods and activity spaces as areas of exposure to density of tobacco outlets. Results showed a higher likelihood of smoking in young adults exposed to greater numbers of tobacco retail stores both around residential neighborhoods and activity spaces [42].

Moreover, limited research has been conducted to examine associations between the presence of smoking accommodation facilities and smoking outcomes, either in relationship to the implementation of smoking bans in public spaces or without such relationships. Following a national ban on indoor smoking in hospitality venues, a French study found that, while indoor smoking decreased significantly, the offer of outdoor smoking spaces increased. This resulted in reported rates of outdoor smoking increasing from 33.6% at baseline to 75.9% at follow-up, suggesting that, although overall individual prevalence declined, in many cases smoking simply

moved outdoors [43]. Interestingly, a recent study examining associations between exposure to patio smoking and smoking cessation found that smokers who were exposed to smoking in patios were less likely to have attempted to cease smoking and more likely to relapse after having made a quit attempt [44]. These studies highlight the relevance of outdoor smoking accommodation facilities as a potential hurdle to smoking cessation. Although it is also possible that these spaces play a role in facilitating smoking initiation (e.g., through exposure to social cues), to date, no empirical studies have examined associations between exposure to smoking accommodation facilities and smoking initiation. Moreover, as with proximity and density of tobacco retail stores, very few studies (if any) have examined associations between the presence of smoking accommodation facilities and smoking outcomes in young adults.

Among a number of conceptual and methodological challenges that must be addressed in order to better understand associations between neighborhood exposures and health outcomes, one important consideration is the definition of appropriate spatial scales. Among the set of challenges related to the analysis of spatial data [45], this issue is central to studies of neighborhoods and health, given that processes underlying associations between neighborhood-level exposures and health outcomes are likely to operate at different scales depending on specific exposure-outcome pairs. For example, the geographic scale at which social networks and distance to retail outlets respectively impact smoking behavior may not be the same. Moreover, the potential impact of these two exposures may operate at different scales in the context of other health outcomes such as depression or cardiovascular disease. Therefore, the operationalization of spatial units must be specific to the associations under study [46–48]. Nonetheless, although some scholars have conducted studies to better understand the impact of using different spatial scale definitions in studies of neighborhoods and health [49–52], to our knowledge few studies of neighborhoods and smoking have examined the potential role of spatial scales in shaping research findings. Importantly, the choice of a spatial scale that does not correspond to the geographical level at which a specific exposure is hypothesized to influence smoking outcomes may translate into an inappropriate operationalization of geographical boundaries, which in turn may result in significant measurement error [53]. This issue is widely recognized in the literature as the "modifiable area unit problem" (MAUP) [54]. In the presence of MAUP, estimates of between-area variation may depend on how boundaries are defined [52,55] and may potentially result in

two types of error. The first, usually called the "scale effect", may arise when different statistical results are obtained depending on the scale at which data are aggregated. The second, usually called the "zoning effect", may occur when different statistical results are obtained depending on how boundaries of a territory are defined [52,53]. Some scholars have called for the use of theories linking spatial scales, mediating processes, and health outcomes prior to the analysis of neighborhood effects [48,56]. Although it would be ideal to define spatial units based on theory, exploratory empirical analyses can allow for initial exploration of spatial issues in the absence of strong theory [57]. In keeping with this notion, the majority of studies of neighborhoods and smoking have used empirical approaches in order to examine associations between exposures and smoking outcomes rather than identifying theory-based spatial unit definitions. In general terms, two broad types of spatial units have been used in the literature. The first is a "proximal" unit type that seeks to capture the more immediate neighborhood environment, either by the use of administrative areas such as census tracts and municipal subdivisions or by the creation of buffer zones with different radii (see for example [22,28]). The second is a "community" unit type that captures environments relevant to health processes that likely operate at a larger scale, such as social norms and community practices (see for example [19,25]).

Another important issue for research on neighborhoods and smoking is the study of associations between exposures and changes in smoking behavior, or lack thereof. Research in this area has typically focused on static smoking variables as their outcome of interest. For example, all of the studies on smoking included in a recent systematic review of health-risk behaviors and neighborhood deprivation examined current smoking status as their outcome [58]. This was also the case for a vast array of studies of different neighborhood exposures and smoking behaviors including current smoking status, smoking initiation and smoking cessation (see for example [35,36,41,59]). Although it is certainly important to examine associations between neighborhood exposures and smoking outcomes using cross-sectional designs, this approach cannot provide information regarding the potential role of neighborhood exposures in influencing changes in smoking status, such as becoming a new smoker, becoming a new non-smoker, or lack of change in any direction. This is particularly important among young adults because this age group experiences significant changes in smoking status. Hammond (2005) proposes that, contrary to hypotheses postulating that smoking behavior becomes largely fixed after high school age, young

adults display variable smoking patterns, with significant smoking uptake taking place after high school age, in many cases shifting repeatedly between daily and occasional smoking [60]. Therefore, regular smoking habits may only develop later in life [61]. Moreover, in comparison to older adults, young adults are more likely to attempt to quit smoking [11].

This variability in smoking behavior in young adults was portrayed in the results of a 2004 study of changes in smoking behavior over a four-year period among a cohort of college students. Within this timeframe, 13% of daily smokers at baseline ceased to smoke and 28% changed their status from daily to occasional smokers, 14% of occasional smokers at baseline became daily smokers, while 51% ceased to smoke, and 11% of non-smokers at baseline initiated occasional smoking. Additionally, 87% of smokers at baseline and 50% of occasional smokers at baseline continued to smoke after four years [62]. Given the significant differences in smoking behavior between college-educated and non-college-educated young adults in the United States [63], these results may not generalize beyond college-educated young adults. Nonetheless, they illustrate the instability of smoking status in this age group.

To date, the bulk of research on neighborhoods and smoking has mainly focused on how neighborhood exposures are associated with static smoking outcomes, such as smoking rates or cessation rates at a specific point in time. Moreover, the vast majority of these studies has devoted their efforts to adolescent and adult populations, while little attention has been paid to young adults. Therefore, it is crucial to understand the role of neighborhood-level exposures in shaping the smoking trajectories in this population.

Additionally, in spite of calls for explicit consideration of spatial scales more specific to the exposures and outcomes under examination, there is a paucity of studies exploring the variability of associations between neighborhood exposures and smoking across spatial scales. Hence, empirical research in this area can contribute to improving knowledge of associations between neighborhood-level exposures and the smoking trajectories in young adults.

The objective of this study was to examine associations between the presence of tobacco retail stores, the presence of smoking accommodation facilities, and self-reported smoking trajectory

among young adults across two nested spatial units in Montreal, Canada. One specific question was asked: For what categories of smoking trajectory and at what spatial scales are these associations statistically significant? We hypothesized that individuals living in neighborhoods with a greater presence of tobacco retail outlets and/or a greater presence of smoking accommodation facilities would be: (1) more likely to change their status from non-smoker to smoker over two years, or to maintain their smoker status during this two-year period; and (2) less likely to change their smoking status from smoker to non-smoker over two years, or to maintain their non-smoker status during this two-year period.

2. METHODS

2.1. Study Sample

This study was conducted in the context of the Interdisciplinary Study of Inequalities in Smoking (ISIS), a cohort study with the objective of better understanding the joint role of individual and neighborhood factors in producing social inequalities in smoking in Montreal among young adults [64]. Analyses were based on the ISIS baseline sample from 2011 to 2012. This sample was composed of non-institutionalized individuals aged 18–25 years, proficient in either English or French, who had been living at their current address for at least one year at time of first contact. An initial random sample of 6020 individuals obtained from Quebec's provincial health insurance program was contacted through a nominalized letter between November 2011 and August 2012. At the end of the recruitment period, 349 individuals refused to participate, 458 were declared ineligible and 3111 could not be reached, resulting in a final sample of 2093 participants. The response rate was 37.6%. While relatively low, these rates are not uncommon in observational studies and could be attributed to unreported moves, inaccurate mailing addresses or to a lack of interest in participating in the study. Participants had similar characteristics to those of participants in the Canadian Community Health Survey (CCHS), a Statistics Canada survey designed to gather health-related data at the health region level [65]. They were, however, in slightly less good physical and mental health and included a lower proportion of daily smokers and a higher proportion of non-smokers. Full details on sampling and survey procedures are available elsewhere [64].

2.2. Description of Neighborhood Spatial Scales

To examine the potential role of different spatial scales in shaping findings regarding associations between neighborhood exposures and smoking trajectory over 2 years among young adults, we used two empirical spatial unit definitions. The first, Health and Social Services catchment areas, called Centres de santé et de services sociaux (CSSSs; n = 12, mean area = 41.7 km2, mean 2011 population = 157,210), may capture processes operating at a larger scale. CSSSs, created in 2004, are administratively-defined geographic service units comprising a local network of health and social services. Territories typically include several partners, notably general practitioners, pharmacies, community organizations, private organizations, specialized health and social services organizations (e.g., hospitals, youth services centres and rehabilitation centres), and multi-sectoral partners [66].

The second definition, sociological neighborhoods (SNs; n = 111, mean area = 4.5 km2, mean 2011 population = 17,000), may capture processes operating within the more immediate neighborhood environment. In contrast to CSSS territories, SNs are community-defined spatial units based both on administrative boundaries and shared perceptions of their residents regarding their history, sense of belonging, infrastructure and services, and population characteristics. These territories were created in 2008 by the Direction de santé publique de Montréal (Montreal's Public Health Department) in partnership with local organizations to better capture the subjective sense of neighborhood experienced by residents. The 111 SNs on the Island of Montreal are nested within the 12 CSSSs and respect Statistics Canada's census tract and dissemination area boundaries. These spatial units are fairly homogeneous in terms of socioeconomic characteristics and are recognized as relevant spatial divisions for local development initiatives [67]. Maps of the territories used for planning and delivery of health and social services on the Island of Montreal can be found elsewhere [68,69].

2.3. Measures of Neighborhood Exposure

Two exposure measures were used in this study. The first was presence of tobacco retail stores at each spatial unit. To construct this measure, data regarding retail outlets legally selling tobacco products were extracted from the 2011 DMTI Enhanced Points of Interest Database [70]. This database is a collection of geocoded address points covering a comprehensive range of land uses,

including tobacco retail stores. This data source was validated using the 2010 database version, for convenience stores and supermarkets. Data were found to be adequately representative, with sensitivity values (the capacity to detect stores present in the field) of 0.59 and 0.75, and positive predictive values (the ability to list only stores that actually existed in the field) of 0.73 and 1.00 for convenience stores and supermarkets respectively [71].

To operationalize the presence of tobacco retail stores, the first step was to compute the number of retail outlets selling tobacco products for each dissemination area (DA) where at least one cohort participant resided. DAs are the smallest geographic census areas in Canada, composed of one or more adjacent dissemination blocks with a population of 400 to 700 persons. There are 3175 DAs on the Island of Montreal, with a mean area of 0.16 km2. A total of 1399 of the 3175 DAs were aggregated to create this exposure. Given that more than half of the DAs had no presence of tobacco retail stores (806 DAs, 57.6% of total), and most of those having presence of tobacco retail stores had only one outlet (369 DAs, 26.4% of total), the values obtained at the DA level were categorized as a dichotomous indicator of presence of at least one retail outlet selling tobacco products in the DA (0 = no presence). A similar approach has been used in previous studies (see, for example, [35]). Alternative approaches to the operationalization of this exposure were explored including density of tobacco retail outlets per 10,000 inhabitants and density of tobacco retail outlets per km2. Analyses revealed relatively low densities per 10,000 population compared to those reported in a recent British study [72]: 96% of the measured DAs had a density of 49.6 per 10,000 inhabitants or lower, the lowest reported value in this study. Since no locally validated standard measures of density of tobacco retail stores that account for population density were available, we chose to use a dichotomous indicator of presence of at least one retail outlet selling tobacco products in the DA.

Second, DA-level values were aggregated at each of the two spatial scales, CSSSs and SNs, and mean values of presence of tobacco retail stores were computed. Finally, in order to contrast neighborhoods with greater presence of this exposure against all other neighborhoods, these values were recoded into a dichotomous indicator. Spatial units at which the highest means were observed (the top quartile) were coded “1” to reflect greater presence, whereas all other areas were coded “0”, reflecting lesser presence of tobacco retail.

The second exposure measure was presence of smoking accommodation facilities. Data used to construct this indicator were extracted from the ISIS observational database. Observational data were collected between June and September 2012 using a validated observation grid [73]. To develop this grid, a theoretical framework [32] conceptualizing the nature of neighborhoods and their potential role in the generation of health inequalities was used. Based on this framework, 86 indicators were constructed, operationalizing a range of neighborhood environmental exposures (e.g., quality of the built environment, neighborhood disorder, presence of facilities accommodating smokers). These indicators were evaluated by trained raters who filled out a paper form. The instrument's inter-rater reliability and temporal stability were assessed through a generalizability study showing that 75% of the indicators in the observation grid were measured with acceptable to excellent reliability [73]. A random sample of street segments (a portion of a street between two intersections, measuring more than 60 meters in length) within Montreal's 35 local community service territories (CLSC) was selected (n = 1399). CLSC territories are administrative units based on the provision of health and social services created by the Ministry of Health and Social Services.

To operationalize the presence of smoking accommodation facilities, street sections having at least one smoking-accommodating feature (ashtrays in commercial outlets, institutions and community organizations, and terraces/patios in bars and restaurants) were coded "1" to indicate presence of such facilities, whereas street sections with no smoking accommodation facilities were coded "0", indicating no presence. The majority of the DAs had no smoking accommodation facilities (1033 DAs, 73.8% of total DAs). DA-level values were aggregated at each of the two spatial scales, CSSSs and SNs, and mean values of presence of tobacco retail stores were computed. Lastly, in order to contrast neighborhoods with greater presence of this exposure against all other neighborhoods, these values were recoded into a dichotomous indicator of smoking accommodation facilities. Spatial units at which the highest means were observed (the top quartile) were coded "1" to reflect greater presence, whereas all other areas were coded "0", reflecting lesser presence.

2.4. Outcome Measures

The dependent variable for this study was self-reported smoking trajectory. To measure this variable, the study population was classified into four categories. These categories were constructed based on self-reported smoking behavior at baseline, measured in 2011, and self-reported previous smoking behavior over a 2-year period. The cut-off point used to construct the categories of smoking trajectory was based on empirical studies of milestones of nicotine dependence and smoking cessation [74–77]. The following baseline ISIS individual survey questions were used in this study:

(1) *Currently, do you smoke cigarettes every day, occasionally, or never?*
(2) *Have you ever smoked an entire cigarette?*
(3) *How old were you when you smoked an entire cigarette for the first time?*
(4) *When was the last time you smoked a cigarette?*

Based on responses to these questions, each participant was allocated to one of four nominal categories. Participants who either never smoked an entire cigarette or reported a non-smoker status at baseline and smoking a cigarette for the last time 2 years ago or longer were categorized as non-smokers for 2 years or longer. Participants who reported an occasional or regular smoker status at baseline and smoking an entire cigarette for the first time 2 years ago or longer were categorized as smokers for 2 years or longer. Participants who reported an occasional or regular smoker status at baseline and smoking an entire cigarette for the first time less than 2 years ago were categorized as smokers for fewer than 2 years. Finally, participants who reported a non-smoker status at baseline and smoking a cigarette for the last time less than 2 years ago were categorized as non-smokers for fewer than 2 years.

2.5. Covariates

Three individual-level covariates were used for this study: age, sex, and educational attainment. All variables were dichotomized. Participants aged 18–21 years were coded “0”, while those aged 22–25 years were coded “1”. Male participants were coded “0”, whereas female participants were coded “1”. Finally, participants who completed high school or lower and were not enrolled in post-

secondary studies at the time of survey were coded “0”, and those who attained at least a post-secondary degree or were enrolled in post-secondary studies at the time of survey were coded “1”.

Fully-adjusted models included a neighborhood socioeconomic position (SEP) variable to examine potential confounding of associations. Neighborhood SEP was operationalized using Pampalon’s material deprivation index quartiles (1 = least deprived, 4 = most deprived) [78]. This index is composed of three indicators: education, work status and income (proportion of persons who have no high-school diploma, the ratio of employment to population and average income), which are widely used as measures of SEP.

2.6. Statistical Analyses

Associations between neighborhood exposures and smoking trajectory were examined using three-level multinomial models: Level-1 = individuals, Level-2 = SNs, Level-3 = CSSSs. Multilevel models are widely used in studies of neighborhood effects, among other reasons, due to their ability to account for correlated or clustered observations and to describe the variability and heterogeneity in the population above and beyond average relationships [79]. Models were built using HLM V.7 software (Scientific Software International Inc.: Skokie, IL, USA), following a “step-up” approach, in which multilevel models are progressively specified. HLM is a statistical software designed to fit a variety of linear and non-linear models using hierarchically-structured data allowing for continuous, count, ordinal, and nominal outcome variables [80].

First, to explore the variance in smoking trajectory at each spatial unit, three-level intercepts-only models were built. Second, level-1 models were built to explain within-neighborhood variability, adding three socio-demographic covariates: age, sex, and educational attainment. Third, level-2 and level-3 models with no level-1 variables were constructed for each measure of exposure at both spatial levels. Finally, random-intercept level-2 and level-3 models including predictors at all levels were built.

3. RESULTS

A total of 1183 female (56.5%) and 910 male (43.5%) young adults (YA) participated in the study. Approximately 51% of them were aged 18 to 21 years (49% were aged 22 to 25 years). The

majority of participants (82.9%) completed or were pursuing post-secondary studies. Information regarding education was missing for 10 participants. The smoking status of the majority of young adults did not change over the two-year period. Most participants were non-smokers for two years or longer (1351 YA, 64.5% of the sample), while almost one-fifth were smokers for two years or longer (409 YA, 19.5% of the sample). 320 participants reported a change in their smoking status over a two-year period: 252 participants (12%) were non-smokers for fewer than two years (12% of the sample), while 68 participants (3.2%) were smokers for fewer than two years. Information regarding smoking trajectory was missing for 13 participants. Since missing data were not imputed, all analyses were conducted based on a subsample of 2070 participants, reflecting missing data for a total of 23 YA. At the SN level, 26 SNs (23.4%) had a greater presence of tobacco retail outlets, while 27 SNs (24.3%) had a greater presence of smoking accommodation facilities. At the CSSS level, three CSSSs (25%) had a greater presence of both exposures. Details appear in Table 1.

Table 1. Descriptive statistics of the analytical sample.

Variable	N (%)
Age	2093
18-21 years, (%)	1065 (50.9)
22-25 years, (%)	1028 (49.1)
Sex	2093
Male, (%)	910 (43.5)
Female, (%)	1183 (56.5)
Education	2093
High School or lower, (%)	347 (16.6)
CEGEP/Trade School or higher, (%)	1736 (82.9)
Missing data	10 (0.5)
Smoking Status	2093
Non-Smoker ≥ 2 years, (%)	1351 (64.5)
Smoker ≥ 2 years, (%)	409 (19.5)
Non-Smoker < 2 years, (%)	252 (12.0)
Smoker < 2 years, (%)	68 (3.2)
Missing data	13 (0.6)
Presence of Tobacco Retail Outlets – SN Level	111
Low presence	85 (76.6)
High Presence	26 (23.4)
Presence of Smoking Accommodation Facilities – SN Level	111
Low presence	84 (75.7)
High Presence	27 (24.3)
Presence of Tobacco Retail Outlets – CSSS Level	12
Low presence	9 (75.0)
High Presence	3 (25.0)
Presence of Smoking Accommodation Facilities – CSSS Level	12
Low presence	9 (75.0)
High Presence	3 (25.0)

Intercepts-only models revealed significant between-area variance in smoking trajectory (Level-3 variance = 0.04027, p-value = 0.009) at the larger spatial unit definition (CSSSs). Conversely, no statistically significant between-area variance (Level-2 variance = 0.00019, p-value > 0.500) was observed at the smaller spatial units (SNs).

Three-level models with individual socio-demographic covariates as predictors showed a significant association between age and smoking trajectory. The likelihood of being a smoker for two years or longer was higher among participants aged 22–25 years vs. 18–21 years (OR = 1.48; 95% CI: 1.18, 1.86). The likelihood of being a smoker for fewer than two years was significantly lower among participants aged 22–25 years (OR = 0.24; 95% CI: 0.13, 0.45). Associations between sex and smoking trajectory showed that female young adults had a lower likelihood of being a smoker for two years or longer in comparison to male young adults (OR = 0.78; 95% CI: 0.63, 0.98). Associations between educational attainment and smoking trajectory were not statistically significant. Details appear in Table 2 below.

Table 2. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from individual-level exposures among 2070 young adults living in Montreal, Canada in 2011–2012.

Variable	Odds Ratio (95% CI)
Age (reference 18-21 years)	
22-25 years - Smoker ≥ 2 yrs.	1.48 (1.18-1.86)**
22-25 years - Non-Smoker < 2 yrs.	1.05 (0.80-1.38)
22-25 years - Smoker < 2 yrs.	0.24 (0.13-0.45)**
22-25 years - Non-Smoker ≥ 2 yrs.	Reference
Sex (reference male)	
Female - Smoker ≥ 2 yrs.	0.78 (0.63-0.98)*
Female - Non-Smoker < 2 yrs.	0.95 (0.72-1.25)
Female - Smoker < 2 yrs.	0.65 (0.40-1.07)
Female - Non-Smoker ≥ 2 yrs.	Reference
Education (reference completed high school or lower)	
Completed/currently CEGEP/Trade School or higher - Smoker ≥ 2 yrs.	1.19 (0.87-1.62)
Completed/currently CEGEP/Trade School or higher - Non-Smoker < 2 yrs.	0.86 (0.61-1.22)
Completed/currently CEGEP/Trade School or higher - Smoker < 2 yrs.	0.69 (0.38-1.26)
Completed/currently CEGEP/Trade School or higher - Non-Smoker ≥ 2 yrs.	Reference

** p-value <0.01; * p-value <0.05

Multilevel models with SN-level exposure variables as predictors showed a statistically significant association between a greater presence of tobacco retail stores and the likelihood of being a smoker for two years or longer. Individuals residing in sociological neighborhoods with greater presence of tobacco retail stores had a greater likelihood of being a smoker for two years

or longer (OR = 1.56; 95% CI: 1.20, 2.05). Associations between a greater presence of smoking accommodation facilities at the SN level and smoking trajectory were not statistically significant.

Different from models with SN-level exposures as predictors, models with CSSS-level exposures as predictors showed a significantly higher likelihood of being a smoker for two years or longer for individuals living in CSSSs with a greater presence of smoking accommodation facilities (OR = 1.77; 95% CI: 1.35, 2.33). In contrast, associations between a greater presence of tobacco retail stores at the CSSS level and smoking trajectory were not statistically significant. Results of models predicting smoking trajectory from SN-level exposures and CSSS-level exposures appear in Tables 3 and 4 respectively.

Table 3. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from SN-level exposures among 2070 adults living in Montreal, Canada in 2011–2012.

Variable	Odds Ratio (95% CI)
Presence of Tobacco Retail Stores (reference lesser presence)	
Greater Presence - Smoker ≥ 2 yrs.	1.56 (1.20-2.05)**
Greater Presence - Non-Smoker < 2 yrs.	0.84 (0.58-1.22)
Greater Presence - Smoker < 2 yrs.	1.46 (0.82-2.61)
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference
Presence of Smoking Accommodation Facilities (reference lesser presence)	
Greater Presence - Smoker ≥ 2 yrs.	1.12 (0.86-1.46)
Greater Presence - Non-Smoker < 2 yrs.	1.07 (0.80-1.45)
Greater Presence - Smoker < 2 yrs.	0.67 (0.37-1.23)
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference

** p-value <0.01

Table 4. Results of multinomial multilevel regression models predicting smoking trajectory over 2 years from CSSS-level exposures among 2070 adults living in Montreal, Canada in 2011–2012.

Variable	Odds Ratio (95% CI)
Presence of Smoking Accommodation Facilities (reference lesser presence)	
Greater Presence - Smoker ≥ 2 yrs.	1.77 (1.35-2.33)**
Greater Presence - Non-Smoker < 2 yrs.	1.04 (0.76-1.43)
Greater Presence - Smoker < 2 yrs.	1.46 (0.85-2.50)
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference
Presence of Tobacco Retail Stores (reference lesser presence)	
Greater Presence - Smoker ≥ 2 yrs.	1.35 (0.93-1.97)
Greater Presence - Non-Smoker < 2 yrs.	1.23 (0.91-1.65)
Greater Presence - Smoker < 2 yrs.	1.46 (0.87-2.45)
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference

** p-value <0.01

Given the statistically significant associations between SN-level greater presence of tobacco retail stores, CSSS-level greater presence of smoking accommodation facilities and the likelihood of being a smoker for two years or longer, a first fully-adjusted model, "Model 1", using these two exposures, as well as age and sex as individual socio-demographic predictors was tested. In this model, associations between age, sex, and the likelihood of being a smoker for two years or longer remained statistically significant. Interestingly, while the association between CSSS-level greater presence of smoking accommodation facilities and smoking trajectory over two years also remained statistically significant, this was not the case for SN-level greater presence of tobacco retail stores.

To examine whether the association between the presence of smoking accommodation facilities and smoking trajectory was confounded by neighborhood socioeconomic position (SEP), a second fully-adjusted model, "Model 2", using neighborhood-level material deprivation was tested. After adjusting for material deprivation, CSSS-level presence of smoking accommodation facilities remained statistically significant, therefore suggesting no confounding of this association by neighborhood SEP. Results for these two models appear in Table 5.

Table 5. Results of fully-adjusted multinomial multilevel regression models predicting smoking trajectory over 2 years among 2070 adults living in Montreal Canada in 2011–2012.

Variable	Model 1	Model 2
	Odds Ratio (95% CI)	
Age (reference 18-21 years)		
22-25 years - Smoker ≥ 2 yrs.	1.44 (1.15-1.81)**	1.48 (1.16-1.86)**
22-25 years - Non-Smoker < 2 yrs.	1.06 (0.81-1.39)	1.06 (0.80-1.37)
22-25 years - Smoker < 2 yrs.	0.23 (0.12-0.43)**	0.23 (0.12-0.44)**
22-25 years - Non-Smoker ≥ 2 yrs.	Reference	Reference
Sex (reference male)		
Female - Smoker ≥ 2 yrs.	0.78 (0.62-0.98)*	0.77 (0.61-0.96)*
Female - Non-Smoker < 2 yrs.	0.95 (0.72-1.25)	0.94 (0.71-1.24)
Female - Smoker < 2 yrs.	0.65 (0.40-1.07)	0.65 (0.40-1.08)
Female - Non-Smoker ≥ 2 yrs.	Reference	Reference
SN-Level Presence of Tobacco Retail Stores (reference lesser presence)		
Greater Presence - Smoker ≥ 2 yrs.	1.24 (0.92-1.67)	-
Greater Presence - Non-Smoker < 2 yrs.	0.79 (0.53-1.19)	-
Greater Presence - Smoker < 2 yrs.	1.41 (0.74-2.68)	-
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference	-
CSSS-Level Presence of Smoking Accommodation Facilities (reference lesser presence)		
Greater Presence - Smoker ≥ 2 yrs.	1.59 (1.18-2.15)**	1.51 (1.08-2.11)**
Greater Presence - Non-Smoker < 2 yrs.	1.12 (0.79-1.58)	0.83 (0.57-1.20)
Greater Presence - Smoker < 2 yrs.	1.44 (0.79-2.62)	1.46 (0.77-2.77)
Greater Presence - Non-Smoker ≥ 2 yrs.	Reference	Reference
Material Deprivation Quartile		
Material Deprivation Quartile - Smoker ≥ 2 yrs.	-	1.20 (0.89-1.61)
Material Deprivation Quartile - Non-Smoker < 2 yrs.	-	1.43 (1.04-1.95)*
Material Deprivation Quartile - Smoker < 2 yrs.	-	1.21 (0.69-2.13)
Material Deprivation Quartile - Non-Smoker ≥ 2 yrs.	-	Reference

** p-value <0.01; * p-value <0.05

4. DISCUSSION

This study examined associations between the presence of tobacco retail stores, the presence of smoking accommodation facilities, and self-reported smoking trajectory over two years among

young adults across two nested spatial units in Montreal, Canada. Results showed that the likelihood of being a smoker for two years or longer was higher among adults living in CSSSs where there was a greater presence of smoking accommodation facilities. Conversely, this association was not statistically significant at the SN level. In contrast, the likelihood of being a smoker for two years or longer was significantly higher among residents of neighborhoods with a greater tobacco retail presence at the smaller spatial unit, but this association was not statistically significant in fully-adjusted models. These results indicate that greater CSSS-level presence of smoking accommodation facilities is associated with being a persistent smoker over a two-year period, above and beyond individual socio-demographic characteristics. Additional analyses revealed that this association was not confounded by neighborhood-level socioeconomic position.

One mechanism that could explain the association between CSSS-level presence of smoking accommodation facilities and the greater likelihood of being a smoker for two years or longer is an increase in access and opportunities to smoke in hospitality venues and public places [43,81]. Evidence regarding smoke-free policies suggests that removing these environmental features contributes to curbing smoking prevalence by reducing smoking opportunities and by de-normalizing smoking [82]. Another potential mechanism underlying associations between the presence of smoking accommodation facilities and persistent smoking in young adults is the exposure to social, visual, and olfactory cues. These cues have been found to be associated with a lower intent to quit and a higher risk of relapse [83–86].

To date, most tobacco control interventions targeting this exposure have resorted to indoor smoking bans in public places, while outdoor smoking restrictions are frequently less stringent, allowing smoking in places such as outdoor patios and terraces. Moreover, these bans for the most part appear to have protected non-smokers from being exposed to second-hand smoke. Studies have shown that smokers tend to more frequently visit outdoor smoking venues [44], and report smoking more cigarettes in these places, in particular among younger individuals [87]. Therefore, future interventions may want to consider an extension of such bans to include outdoor public places, such as hospitality venues. The importance of extending smoking bans to outdoor spaces has been recognized by the Government of Quebec, who recently passed a bill prohibiting smoking in a variety of outdoor spaces including patios and terraces [88].

No significant associations between the two neighborhood exposures and other categories of smoking trajectory over two years were found. In the case of changes leading to a non-smoker status at baseline (non-smokers for two years or longer and non-smokers for fewer than two years), a lack of significant associations with a greater presence of tobacco retail outlets and a greater presence of smoking accommodation facilities appears to be a reasonable expectation. This is notable because these exposures were operationalized to detect associations with the greatest levels of exposure (i.e., highest quartile of exposure vs. all other quartiles). The reverse may have resulted in findings of significant associations between the lowest levels of exposure and the likelihood of being a non-smoker at baseline. A greater presence of tobacco retail outlets is likely to increase accessibility to tobacco products [89] and exposure to point-of-sale marketing [90–92], while, as discussed above, it could be hypothesized that a greater presence of smoking accommodation facilities increases not only opportunities to smoke in public venues, but also social acceptance and exposure to social, visual and olfactory stimuli, all of which can trigger smoking. Therefore, it is more likely that greater levels of these exposures are associated with changes leading to a smoking status at baseline rather than the reverse.

While it is possible for a greater presence of tobacco retail outlets and smoking accommodation facilities to be associated with the likelihood of being a smoker for less than two years, the lack of statistically significant associations with this category of smoking trajectory over two years may suggest that these exposures are not sufficient to contribute to smoking initiation. A similar absence of statistically significant associations was found in a recent study of incidence and determinants of smoking initiation among young adults that examined three neighborhood-level exposures (tolerance of smoking around corner stores, around schools and around restaurants) likely to operate through mechanisms similar to those thought to underlie associations between the presence of tobacco retail outlets, smoking accommodation facilities and smoking trajectory over two years among young adults [4].

Another potential explanation for the absence of statistically significant associations in three of the four categories examined in this study is the instability of smoking status in this age group. Young adulthood is increasingly recognized as a crucial developmental period during which a number of important changes take place, including those related to health behaviors [9]. Since

young adults may experience frequent changes from smoking to non-smoking and vice versa, it is possible that measurement at baseline captured one of these changes, albeit not with enough time for them to become more solidly established behaviors. Repeated measures designs may be helpful in addressing this issue.

The results of this study echo theoretical propositions regarding the specificity of scales at which health-related processes take place. As Diez-Roux (2007) proposes, "it is very plausible that areas of different size could be relevant for different processes and different health outcomes" [57] (p. 18). Therefore, as suggested by Gauvin et al. (2007), the use of an exposure-specific and outcome-specific spatial scale approach is likely to be best suited to the study of neighborhood effects on health [93]. The significant association between a greater presence of tobacco retail at the SN level (rather than at the CSSS level) and the likelihood of being a smoker for two years or longer suggests that geographic proximity may play an important role in facilitating access to tobacco products. This is in line with findings in the literature [36,37,94,95]. However, evidence of mechanisms underlying the association of presence of smoking accommodation facilities at the CSSS level rather than at the SN level are currently lacking. Future studies are warranted to explore this issue further.

In sum, two important issues regarding neighborhood-level exposures and smoking in young adults are highlighted in this study. First, differences in associations between neighborhood-level exposures and the likelihood of being a smoker for two years or longer suggest that additional knowledge regarding smoking outcomes in young adults can be gained by examining not only smoking prevalence, but also how this population goes through different stages of smoking behavior. Specific to this study, results suggest that variability in smoking trajectory over two years among young adults is explained, at least in part, by a greater CSSS-level presence of smoking accommodation facilities. Second, as evidenced by the differences in magnitude of associations between the specific exposures examined in this study and smoking trajectory over two years depending on the geographic scale of analysis, these results suggest that there is a need to consider spatial unit definitions appropriate to the specific exposure-outcome associations under analysis. Doing so is likely to contribute to the reduction of measurement error due to an inadequate operationalization of spatial scales.

This study also has a number of limitations. First, given the cross-sectional nature of its design, it was not possible to establish causal links between a greater CSSS-level presence of smoking accommodation facilities and the likelihood of being a smoker for two years or longer. Second, there is potential for selection bias, given the relatively low response rate (37.6%) to the individual questionnaire. Of note, non-responders were more likely to be male and to reside in most-deprived areas than responders. Third, even though the data source used to measure presence of tobacco retail outlets was validated and found to be adequately representative, misclassification bias cannot be ruled out. Fourth, given that data regarding presence of smoking accommodation facilities were collected at the dissemination area level, there is potential for understatement of this exposure in neighborhoods for which a more limited number of observations were conducted (e.g., in larger-area neighborhoods where no commercial street sections were observed). A larger sample could help examine this issue more thoroughly. Finally, neighborhood exposures were measured only once, and in consequence any changes that may have occurred were not taken into account. Given that changes in neighborhood-level exposures may be associated with the smoking trajectory, future studies could focus on the examination of changes in exposures across time.

5. CONCLUSIONS

Our findings highlight the importance of studying not only static smoking outcome measures such as smoking prevalence at a specific time-point, but also the smoking trajectory over two years. This is particularly important in young adults who experience repeated changes in smoking behavior throughout this life stage. Additionally, in line with calls for greater specificity in neighborhood effects studies [46–48,96], our results point to the relevance of spatial scale considerations in the studies of neighborhoods and smoking. Scale-dependent differences in associations between the two exposures examined in this study, and smoking trajectory over two years above and beyond individual socio-demographic characteristics, suggest that processes related to smoking in young adults take place at different scales and differ as a function of the specific exposures and outcomes being examined. Further research on specific neighborhood exposures and smoking trajectories in young adults is warranted.

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REFERENCES

1. Baliunas, D.; Patra, J.; Rehm, J.; Popova, S.; Kaiserman, M.; Taylor, B. Smoking-attributable mortality and expected years of life lost in Canada 2002: Conclusions for prevention and policy. Chronic Dis. Can. 2007, 27, 154–162.

2. Reid, J.L.; Hammond, D.; Rynard, V.L.; Burkhalter, R. *Tobacco Use in Canada: Patterns and Trends, 2015 Edition*; Propel Centre for Population Health Impact, University of Waterloo: Waterloo, ON, Canada, 2015.

3. Bernat, D.H.; Klein, E.G.; Forster, J.L. Smoking Initiation During Young Adulthood: A Longitudinal Study of a Population-Based Cohort. J. Adolesc. Health 2012, 51, 497–502.

4. O'Loughlin, J.L.; Dugas, E.N.; O'Loughlin, E.K.; Karp, I.; Sylvestre, M.P. Incidence and Determinants of Cigarette Smoking Initiation in Young Adults. J. Adolesc. Health 2014, 54, 26–32.

5. Tjora, T.; Hetland, J.; Aaro, L.E.;Wold, B.; Overland, S. Late-onset smokers: How many, and associations with health behaviours and socioeconomic status. Scand. J. Public Health 2012, 40, 537–543.

6. Myers, M.G.; Doran, N.M.; Trinidad, D.R.;Wall, T.L.; Klonoff, E.A. A Prospective Study of Cigarette Smoking Initiation During College: Chinese and Korean American Students. Health Psychol. 2009, 28, 448–456.

7. Tercyak, K.P.; Rodriguez, D.; Audrain-McGovern, J. High School Seniors' Smoking Initiation and Progression 1 Year After Graduation. Am. J. Public Health 2007, 97, 1397–1398.

8. Freedman, K.S.; Nelson, N.M.; Feldman, L.L. Smoking Initiation among Young Adults in the United States and Canada, 1998–2010: A Systematic Review. Prev. Chronic Dis. 2011, 9, 1–14.

9. Bonnie, R.J.; Stroud, C.; Breiner, H. *Investing in the Health and Well-Being of Young Adults*; National Academies Press: Washington, DC, USA, 2015.

10. Ling, P.M.; Glantz, S.A. Why and How the Tobacco Industry Sells Cigarettes to Young Adults: Evidence From Industry Documents. Am. J. Public Health 2002, 92, 908–916.

11. Suls, J.M.; Luger, T.M.; Curry, S.J.; Mermelstein, R.J.; Sporer, A.K.; An, L.C. Efficacy of Smoking-Cessation Interventions for Young Adults. Am. J. Prev. Med. 2012, 42, 655–662.

12. Barnett, R.; Pearce, J.; Moon, G. Community inequality and smoking cessation in New Zealand, 1981–2006. Soc. Sci. Med. 2009, 68, 876–884.

13. Chahine, T.; Subramanian, S.V.; Levy, J.I. Sociodemographic and geographic variability in smoking in the U.S.: A multilevel analysis of the 2006–2007 Current Population Survey, Tobacco Use Supplement. Soc. Sci. Med. 2011, 73, 752–758.

14. Chuang, Y.C.; Cubbin, C.; Ahn, D.; Winkleby, M.A. Effects of neighborhood socioeconomic status and convenience store concentration on individual level smoking. J. Epidemiol. Community Health 2005, 59, 568–573.

15. Datta, G.D.; Subramanian, S.V.; Colditz, G.A.; Kawachi, I.; Palmer, J.R.; Rosenberg, L. Individual, neighborhood, and state-level predictors of smoking among US Black women: A multilevel analysis. Soc. Sci. Med. 2006, 63, 1034–1044.

16. Duncan, C.; Jones, K.; Moon, G. Smoking and deprivation: Are there neighborhood effects? Soc. Sci. Med. 1999, 48, 497–505.

17. Ellaway, A.; Macintyre, S. Are perceived neighborhood problems associated with the likelihood of smoking? J. Epidemiol. Community Health 2009, 63, 78–80.

18. Frohlich, K.L.; Potvin, L.; Gauvin, L.; Chabot, P. Youth smoking initiation: Disentangling context from composition. Health Place 2002, 8, 155–166.

19. Hatzenbuehler, M.L.;Wieringa, N.F.; Keyes, K.M. Community-Level Determinants of Tobacco Use Disparities in Lesbian, Gay, and Bisexual Youth: Results From a Population-Based Study. Arch. Pediatr. Adolesc. Med. 2011, 165, 527–532.

20. Leatherdale, S.T.; Strath, J.M. Tobacco Retailer Density Surrounding Schools and Cigarette Access Behaviors among Underage Smoking Students. Ann. Behav. Med. 2007, 33, 105–111.

21. Lin, E.Y.; Witten, K.; Casswell, S.; You, R.Q. Neighborhood matters: Perceptions of neighborhood cohesiveness and associations with alcohol, cannabis and tobacco use. Drug Alcohol. Rev. 2012, 31, 402–412.

22. Miles, R. Neighborhood disorder and smoking: Findings of a European urban survey. Soc. Sci. Med. 2006, 63, 2464–2475.

23. Reijneveld, S.A. The impact of individual and area characteristics on urban socioeconomic differences in health and smoking. Int. J. Epidemiol. 1998, 27, 33–40.

24. Ross, C.E. Walking, exercising, and smoking: Does neighborhood matter? Soc. Sci. Med. 2000, 265–274.

25. Siahpush, M.; Borland, R.; Taylor, J.; Singh, G.K.; Ansari, Z.; Serraglio, A. The association of smoking with perception of income inequality, relative material well-being, and social capital. Soc. Sci. Med. 2006, 63, 2801–2812.

26. Smith, K.C.; Stillman, F.; Bone, L.; Yancey, N.; Price, E.; Belin, P.; Kromm, E.E. Buying and Selling Loosies in Baltimore: The Informal Exchange of Cigarettes in the Community Context. J. Urban Health 2007, 84, 494–507.

27. Turrell, G.; Hewitt, B.A.; Miller, S.A. The influence of neighborhood disadvantage on smoking cessation and its contribution to inequalities in smoking status. Drug Alcohol. Rev. 2012, 31, 645–652.

28. Van Lenthe, F.J.; Mackenbach, J.P. Neighborhood and individual socioeconomic inequalities in smoking: The role of physical neighborhood stressors. J. Epidemiol. Community Health 2006, 60, 699–705.

29. Tessier, S.; Drouin, M.; Simoneau, M.E. *Montréal sans Tabac: Plan de Lutte Contre le Tabagisme 2012–2015*; Agence de la Santé et des Services Sociaux de Montréal: Montreal, QC, Canada, 2013.

30. Ross, N.A.; Tremblay, S.S.; Graham, K. Neighborhood influences on health in Montreal, Canada. Soc. Sci. Med. 2004, 59, 1485–1494.

31. Macintyre, S.; Ellaway, A. Ecological Approaches: Rediscovering the Role of the Physical and Social Environment. In *Social Epidemiology*; Berkman, L.F., Kawachi, I., Eds.; Oxford University Press: Oxford, UK, 2000; pp. 332–348.

32. Bernard, P.; Charafeddine, R.; Frohlich, K.L.; Daniel, M.; Kestens, Y.; Potvin, L. Health inequalities and place: A theoretical conception of neighborhood. Soc. Sci. Med. 2007, 65, 1839–1852.

33. Kandula, N.R.; Wen, M.; Jacobs, E.A.; Lauderdale, D.S. Association Between Neighborhood Context and Smoking Prevalence Among Asian Americans. Am. J. Public Health 2009, 99, 885–892.

34. Pearce, J.; Hiscock, R.; Moon, G.; Barnett, R. The neighborhood effects of geographical access to tobacco retailers on individual smoking behaviour. J. Epidemiol. Community Health 2009, 63, 69–77.

35. Marashi-Pour, S.; Cretikos, M.; Lyons, C.; Rose, N.; Jalaludin, B.; Smith, J. The association between the density of retail tobacco outlets, individual smoking status, neighborhood socioeconomic status and school locations in New South Wales, Australia. Spat. Spatiotemporal Epidemiol. 2015, 12, 1–7.

36. Halonen, J.I.; Kivimäki, M.; Kouvonen, A.; Pentti, J.; Kawachi, I.; Subramanian, S.V.; Vahtera, J. Proximity to a tobacco store and smoking cessation: A cohort study. Tob. Control 2013, 23, 1–6.

37. Reitzel, L.R.; Cromley, E.K.; Li, Y.; Cao, Y.; Dela Mater, R.; Mazas, C.A.; Cofta-Woerpel, L.; Cinciripini, P.M.; Wetter, D.W. The Effect of Tobacco Outlet Density and Proximity on Smoking Cessation. Am. J. Public Health 2011, 101, 315–320.

38. McCarthy, W.J.; Mistry, R.; Lu, Y.; Patel, M.; Zheng, H.; Dietsch, B. Density of Tobacco Retailers Near Schools: Effects on Tobacco Use among Students. Am. J. Public Health 2009, 99, 2006–2013.

39. Scully, M.; McCarthy, M.; Zacher, M.;Warne, C.;Wakefield, M.; White, V. Density of tobacco retail outlets near schools and smoking behaviour among secondary school students. Aust. N. Z. J. Public Health 2013, 37, 574–578.

40. Shortt, N.K.; Tisch, C.; Pearce, J.; Richardson, E.A.; Mitchell, R. The density of tobacco retailers in home and school environments and relationship with adolescent smoking behaviours in Scotland. Tob. Control 2014.

41. Cantrell, J.; Pearson, J.L.; Anesetti-Rothermel, A.; Xiao, H.; Kirchner, T.R.; Vallone, D. Tobacco Retail Outlet Density and Young Adult Tobacco Initiation. Nicotine Tob. Res. 2015.

42. Shareck, M.; Kestens, Y.; Vallée, J.; Datta, G.; Frohlich, K.L. The added value of accounting for activity space when examining the association between tobacco retailer availability and smoking among young adults. Tob. Control 2015.

43. Kennedy, R.D.; Behm, I.; Craig, L.; Thompson, M.E.; Fong, G.T.; Guignard, R.; Beck, F. Outdoor smoking behaviour and support for outdoor smoking restrictions before and after France's national smoking ban. Eur. J. Public Health 2012, 22, 29–34.

44. Chaiton, M.; Diemert, L.; Zhang, B.; Kennedy, R.D.; Cohen, J.E.; Bondy, S.J.; Ferrence, R. Exposure to smoking on patios and quitting: A population representative longitudinal cohort study. Tob. Control 2014.

45. Fotheringham, S.A.; Rogerson, P.A. GIS and spatial analytical problems. Int. J. Geogr. Inf. Syst. 1993, 7, 3–19.

46. Diez Roux, A.V. Investigating Neighborhood and Area Effects on Health. Am. J. Public Health 2001, 91, 1783–1789.

47. Macintyre, S.; Ellaway, A.; Cummins, S. Place effects on health: How can we conceptualise, operationalise and measure them? Soc. Sci. Med. 2002, 125–139.

48. Messer, L.C. Invited Commentary: Beyond the Metrics for Measuring Neighborhood Effects. Am. J. Epidemiol. 2007, 165, 868–871; discussion 872–863.

49. Cockings, S.; Martin, D. Zone design for environment and health studies using pre-aggregated data. Soc. Sci. Med. 2005, 60, 2729–2742.

50. Haynes, R.; Daras, K.; Reading, R.; Jones, A. Modifiable neighborhood units, zone design and residents' perceptions. Health Place 2007, 13, 812–825.

51. Krieger, N.; Chen, J.T.; Waterman, P.D.; Soobader, M.J.; Subramanian, S.V.; Carson, R. Geocoding and Monitoring of US Socioeconomic Inequalities in Mortality and Cancer Incidence: Does the Choice of Area-based Measure and Geographic Level Matter?: The Public Health Disparities Geocoding Project. Am. J. Epidemiol. 2002, 156, 471–482.

52. Schuurman, N.; Bell, N.; Dunn, J.R.; Oliver, L. Deprivation indices, population health and geography: An evaluation of the spatial effectiveness of indices at multiple scales. J. Urban Health 2007, 84, 591–603.

53. Osypuk, T.; Galea, S. What Level Macro? Choosing Appropriate Levels to Assess How Place Influences Population Health. In *Macrosocial Determinants of Population Health*; Galea, S., Ed.; Springer: New York, NY, USA, 2007; pp. 399–435.

54. Openshaw, S. The Modifiable Areal Unit Problem. In *Concepts and Techniques in Modern Geography*; Geo Books: Norwich, UK, 1984.

55. Stafford, M.; Duke-Williams, O.; Shelton, N. Small area inequalities in health: Are we underestimating them? Soc. Sci. Med. 2008, 67, 891–899.

56. O'Campo, P. Invited Commentary: Advancing Theory and Methods for Multilevel Models of Residential Neighborhoods and Health. Am. J. Epidemiol. 2003, 157, 9–13.

57. Diez Roux, A.V. Neighborhoods and health: Where are we and were do we go from here? Rev. Epidemiol. Sante Publique 2007, 55, 13–21.

58. Algren, M.H.; Bak, C.K.; Berg-Beckhoff, G.; Andersen, P.T. Health-Risk Behaviour in Deprived Neighborhoods Compared with Non-Deprived Neighborhoods: A Systematic Literature Review of Quantitative Observational Studies. PLoS ONE 2015, 10, e0139297.

59. Brown, Q.L.; Milam, A.J.; Smart, M.J.; Johnson, R.M.; Linton, S.L.; Furr-Holden, C.D.; Ialongo, N.S. Objective and perceived neighborhood characteristics and tobacco use among young adults. Drug Alcohol Depend. 2014, 134, 370–375.

60. Hammond, D. Smoking behaviour among young adults: Beyond youth prevention. Tob. Control 2005, 14, 181–185.

61. Lantz, P.M. Smoking on the rise among young adults: Implications for research and policy. Tob. Control 2003, 12, i60–i70.

62. Wetter, D.W.; Kenford, S.L.;Welsch, S.K.; Smith, S.S.; Fouladi, R.T.; Fiore, M.C.; Baker, T.B. Prevalence and predictors of transitions in smoking behavior among college students. Health Psychol. 2004, 23, 168–177.

63. Green, M.P.; McCausland, K.L.; Xiao, H.; Duke, J.C.; Vallone, D.M.; Healton, C.G. A Closer Look at Smoking among Young Adults: Where Tobacco Control Should Focus Its Attention. Am. J. Public Health 2007, 97, 1427–1433.

64. Frohlich, K.L.; Shareck, M.; Vallee, J.; Abel, T.; Agouri, R.; Cantinotti, M.; Daniel, M.; Dassa, C.; Datta, G.; Gagne, T.; et al. Cohort Profile: The Interdisciplinary Study of Inequalities in Smoking (ISIS). Int. J. Epidemiol. 2015.

65. Statistics Canada. Canadian Community Health Survey—Annual Component (CCHS). Available online: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226 (accessed on 3 June 2015).

66. Santé et Services Sociaux Québec. Health and Social Services System in Brief. Available online: http://www.msss.gouv.qc.ca/en/sujets/organisation/en-bref/gouvernance-et-organisation/reseauxlocaux- de-services (accessed on 3 June 2015).

67. Collectif Quartier. Atlas Santé Montréal. Available online: http://www.collectifquartier.org/carte/atlassante-montreal/ (accessed on 18 November 2015).

68. Gouvernement du Québec; Espace Montréalais d'Information sur la Santé (EMIS). Territoires sociosanitaires à Montreal. Available online: http://emis.santemontreal.qc.ca/fileadmin/emis/Outil/Atlas/carte_pdf/decoupages/CSSS_CLSC_Voisinages_Montreal_01.pdf (accessed on 22 December 2015).

69. Gouvernement du Québec; Espace Montréalais d'Information sur la Santé (EMIS). Les Voisinages de Montréal. Available online: http://emis.santemontreal.qc.ca/fileadmin/emis/Outil/Atlas/carte_pdf/decoupages/voisinage.pdf (accessed on 22 December 2015).

70. DMTI Spatial Inc. Enhanced Points of Interest v.3 [Computer File]; DMTI Spatial Inc.: Markham, ON, Canada, 2011.

71. Clary, C.; Kestens, Y. Field validation of secondary data sources: A novel measure of representativity applied to a Canadian food outlet database. Int. J. Behav. Nutr. Phys. Act. 2013, 10, 1–9.

72. Shortt, N.K.; Tisch, C.; Pearce, J.; Mitchell, R.; Richardson, E.A.; Hill, S.; Collin, J. A cross-sectional analysis of the relationship between tobacco and alcohol outlet density and neighborhood deprivation. BMC Public Health 2015, 15, 1–9.

73. Shareck, M.; Dassa, C.; Frohlich, K.L. Improving the measurement of neighborhood characteristics through systematic observation: Inequalities in smoking as a case study. Health Place 2012, 18, 671–682.

74. Dierker, L.; He, J.; Kalaydjian, A.; Swendsen, J.; Degenhardt, L.; Glantz, M.; Conway, K.; Anthony, J.; Chiu, W.T.; Sampson, N.A.; et al. The Importance of Timing of Transitions for Risk of Regular Smoking and Nicotine Dependence. Ann. Behav. Med. 2008, 36, 87–92.

75. Dierker, L.; Swendsen, J.; Rose, J.; He, J.; Merikangas, K.; Tobacco Etiology Research Network. Transitions to Regular Smoking and Nicotine Dependence in the Adolescent National Comorbidity Survey (NCS-A). Ann. Behav. Med. 2012, 43, 394–401.

76. O'Loughlin, J.; Gervais, A.; Dugas, E.; Meshefedjian, G. Milestones in the Process of Cessation Among Novice Adolescent Smokers. Am. J. Public Health 2009, 99, 499–504.

77. Zhan, W.; Dierker, L.C.; Rose, J.S.; Selya, A.; Mermelstein, R.J. The Natural Course of Nicotine Dependence Symptoms Among Adolescent Smokers. Nicotine Tob. Res. 2012, 14, 1445–1452.

78. Pampalon, R.; Hamel, D.; Gamache, P.; Philibert, M.D.; Raymond, G.; Simpson, A. An Area-based Material and Social Deprivation Index for Public Health in Québec and Canada. Can. J. Public Health 2012, 103, S17–S22.

79. Blakely, T.; Subramanian, S.V. Multilevel Studies. In Methods in Social Epidemiology; Oakes, J.M., Kaufman, J., Eds.; Jossey-Bass: San Francisco, CA, USA, 2006; pp. 316–340.

80. Tabachnick, B.G.; Fidell, L.S. Multilevel Linear Modeling. In *Using Multivariate Statistics, 6th ed*; Pearson Education: Boston, MA, USA, 2013; pp. 786–861.

81. Chan, J.; Burnett, T.; Baillie, R.; Blomfield, S.; Cameron-Christie, P.; Dickson, J.; Fleishl, W.; Ghandi, S.; Gordon, K.; Heo, J.; et al. Smoking in outdoor areas of bars and cafés: Large differences between midday and evening prevalences. Drugs Educ. Prev. Policy 2014, 21, 484–488.

82. International Agency for Research on Cancer (IARC). *Handbooks of Cancer Prevention, Tobacco Control, Vol. 13: Evaluating the Effectiveness of Smoke-Free Policies*; IARC: Lyon, France, 2009.

83. Cortese, B.M.; Uhde, T.W.; LaRowe, S.D.; Stein, S.V.; Freeman,W.C.; McClernon, F.J.; Brady, K.T.; Hartwell, K.J. Olfactory Cue Reactivity in Nicotine-Dependent Adult Smokers. Psychol. Addict. Behav. 2015, 29, 91–96.

84. Mead, E.L.; Rimal, R.N.; Ferrence, R.; Cohen, J.E. Understanding the sources of normative influence on behavior: The example of tobacco. Soc. Sci. Med. 2014, 115, 139–143.

85. Versace, F.; Engelmann, J.M.; Robinson, J.D.; Jackson, E.F.; Green, C.E.; Lam, C.Y.; Minnix, J.A.; Karam-Hage, M.A.; Brown, V.L.; Wetter, D.W. Prequit FMRI responses to pleasant cues and cigarette-related cues predict smoking cessation outcome. Nicotine Tob. Res. 2014, 16, 697–708.

86. Zhou, X.; Nonnemaker, J.; Sherrill, B.; Gilsenan, A.W.; Coste, F.; West, R. Attempts to quit smoking and relapse: Factors associated with success or failure from the ATTEMPT cohort study. Addict. Behav. 2009, 34, 365–373.

87. Trotter, L.; Wakefield, M.; Borland, R. Socially cued smoking in bars, nightclubs, and gaming venues: A case for introducing smoke-free policies. Tob. Control 2002, 11, 300–304.

88. Gouvernement du Québec. Bill 44: An Act to Bolster Tobacco Control, 41st Parliament. 2015. Available online: http://www.assnat.qc.ca/en/travaux-parlementaires/projets-loi/projet-loi-44-41-1.html (accessed on 21 December 2015).

89. Novak, S.P.; Reardon, S.F.; Raudenbush, S.W.; Buka, S.L. Retail Tobacco Outlet Density and Youth Cigarette Smoking: A Propensity-Modeling Approach. Am. J. Public Health 2006, 96, 670–676.

90. Burton, S.; Clark, L.; Jackson, K. The association between seeing retail displays of tobacco and tobacco smoking and purchase: Findings from a diary-style survey. Addiction 2012, 107, 169–175.

91. Germain, D.; McCarthy, M.;Wakefield, M. Smoker sensitivity to retail tobacco displays and quitting: A cohort study. Addiction 2010, 105, 159–163.

92. Henriksen, L.; Schleicher, N.C.; Feighery, E.C.; Fortmann, S.P. A Longitudinal Study of Exposure to Retail Cigarette Advertising and Smoking Initiation. Pediatrics 2010, 126, 232–238.

93. Gauvin, L.; Robitaille, E.; Riva, M.; McLaren, L.; Dassa, C.; Potvin, L. Conceptualizing and Operationalizing Neighborhoods: The Conundrum of Identifying Territorial Units. Can. J. Public Health 2007, 98, S18–S26.

94. Cantrell, J.; Anesetti-Rothermel, A.; Pearson, J.L.; Xiao, H.; Vallone, D.; Kirchner, T.R. The impact of the tobacco retail outlet environment on adult cessation and differences by neighborhood poverty. Addiction 2015, 110, 152–161.

95. Chaiton, M.; Mecredy, G.; Rehm, J.; Samokhvalov, A.V. Tobacco retail availability and smoking behaviours among patients seeking treatment at a nicotine dependence treatment clinic. Tob. Induc. Dis. 2014, 12.

96. Riva, M.; Gauvin, L.; Barnett, T.A. Toward the next generation of research into small area effects on health: A synthesis of multilevel investigations published since July 1998. J. Epidemiol. Community Health 2007, 61, 853–861.

ARTICLE 2

Title: Residential environments and smoking behaviour patterns among young adults: A prospective study using data from the *Interdisciplinary Study of Inequalities in Smoking* cohort

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ABSTRACT

Young adults have the highest prevalence of smoking among all age groups. Studies have shown associations between presence/density of tobacco retail and presence of smoker accommodation and smoking prevalence. However, little is known about their potential to influence different smoking patterns including initiation, maintenance, or cessation. This is important because smoking behaviour patterns in young adults may be subject to ongoing changes. Moreover, smoking pattern determinants may be different to those of smoking prevalence, and feature-pattern associations may be scale-dependent, requiring the consideration of different analytical spatial units. We examined associations between prospectively-measured smoking behaviour patterns and presence/density of tobacco retail, and presence of smoker accommodation facilities across 2 nested spatial units in Montreal, Canada. Data were from 18-25 year-old Montreal residents who had participated in the *Interdisciplinary Study of Inequalities in Smoking* cohort both at baseline in 2011-2012 and follow-up in 2014 and resided in the same area at follow-up. 2-year smoking behaviour patterns were assessed for 2 cohorts based on participants' smoking status at baseline. Associations were examined using multilevel logistic models. Young adults who were smokers at baseline residing in areas with higher local-level presence of tobacco retail were less likely to quit smoking(i.e.: to be non-smokers for fewer than 2 years). Higher presence of smoker accommodation was not associated with smoking patterns at any scale. Findings provide evidence of scale-specific associations between residential environment features and smoking behaviour patterns in young adults, which may point to specific exposure-outcome processes underlying these associations.

INTRODUCTION

Smoking is the leading cause of preventable premature death worldwide, accounting for more than 7 million deaths per year.[1] Although most developed countries have witnessed a sustained decline in prevalence over the last decades, significant socio-demographic inequalities persist. This is the case in Canada where young adults show the highest smoking prevalence of all age groups.[2] These trends are concerning given that further smoking uptake occurs during young adulthood.[3]

As with other health outcomes, residential environment features play a role in mediating and shaping smoking behaviour.[4] A significant body of research shows associations between these features and smoking, in particular proximity (i.e.: presence within areas around residential addresses), and density of tobacco retail stores (i.e.: store counts per spatial unit), and presence of smoker accommodation facilities (e.g.: patios/outdoor terraces) above and beyond individual-level characteristics.[4 5]

To date, most of this research is cross-sectional, thereby precluding the examination of plausible causal links. Moreover, it is almost exclusively focused on static outcomes such as being a smoker or quit attempts at discrete time points.[6] Although these studies provide evidence of associations between residential environmental features and smoking, they have limitations, notably because they cannot inform about their potential to influence different behaviours such as smoking initiation, cessation or maintenance. Although much of the current research is concerned with cessation rates among smokers and initiation rates among non-smokers, other smoking patterns, notably the maintenance of a smoker or a non-smoker status, require examination. This is particularly important in young adults because they experience repeated shifts between smoking and non-smoking bouts, and between daily and occasional smoking.[7] Thus, regular smoking habits in this population may become established during this period or even develop later in life.[8]

Furthermore, although limited, research in this area suggests that different smoking behaviour patterns may be influenced by different sets of features. For example, a Californian study of smoking in adolescents and density and proximity of tobacco outlets near their schools[9] showed that these features were associated with smoking initiation, but not with maintenance.

Putative processes linking environmental features and smoking behaviour patterns may also operate at different scales.[10 11] Relevant spatial definitions may therefore differ depending on the specific exposure-outcome pair being examined. For example, mechanisms linking a higher presence/density of tobacco retail outlets and smoking behaviour are thought to operate at a local level (e.g.: residential neighbourhoods), through increased accessibility to tobacco products,[12-15] higher exposure to point-of-sale promotions,[16-18] environmental cues,[19] and local normalization of smoking.[5 20-22] On the other hand, processes related to the presence of smoker accommodation facilities may operate at a more distal scale (e.g.: regional administrative areas), potentially due to regional variability in willingness and capability to enforce tobacco regulations and laws.[23-25]

Given these potential differences, scale-dependent associations should be examined in studies in this area, as they can help mitigate measurement error, contribute to the identification of pertinent spatial units, and ultimately inform tobacco control initiatives. However, despite calls to do so,[26] a 2016 systematic review of neighbourhood effects research in the United States,[27] showed that very few studies (3.9%) explicitly addressed spatial scale issues.

Ideally, the choice of spatial units should be theoretically-driven. Nonetheless, since theories linking spatial scales, mediating processes and outcomes are still scarce,[11] several scholars propose to approach uncertain local area boundaries using multiple spatial units to compare the strength of associations between variables at different scales.[11 28-30]

In this paper, we propose to advance knowledge regarding the association between three residential environment features, namely presence and density of tobacco retail and presence of smoker accommodation facilities, and young adult smoking behaviour patterns using a prospective design.

Two core questions were asked: 1) what smoking behaviour patterns are associated with each of the residential environment features? and 2) at what scales are these associations statistically significant? Based on the existing literature, we hypothesized that associations between tobacco retail presence/density and smoking behaviour patterns would be stronger at a more local scale,

and that associations between these patterns and presence of smoker accommodation facilities would be stronger at a more distal scale.

METHODS

Sampling

Analyses were performed on data from the Interdisciplinary Study of Inequalities in Smoking (ISIS). ISIS is a cohort study aimed at advancing knowledge of the joint role of individual and neighbourhood factors in producing social inequalities in smoking among young adults living in Montreal.[31] Study participants were recruited through sampling of members of the province of Quebec's universal and publicly funded health insurance programme. An initial list of 6,020 randomly selected non-institutionalized individuals aged 18 to 25 years who had resided at the same address for at least one year was used to recruit participants.

First contact was established via a letter of invitation, and upon acceptance to participate, an online baseline questionnaire was completed between November 2011 and September 2012. Other response methods were made available upon request. A total of 2,093 individuals completed this questionnaire, for a final response rate of 37.6%. These rates are common in observational studies and likely reflect unreported moves, inaccurate mailing addresses, or lack of interest in participating in the study.

A follow-up questionnaire was completed two years after cohort inception as a result of prompting through e-mail, telephone, and letter reminders. Retention rate at follow up was 73.3%, for a total of 1,457 participants. Full sampling and survey details are available elsewhere.[31] For the purposes of this study, analyses were restricted to participants who resided in the same area at baseline and follow up (n=1,116).

Operationalization of Spatial Scales

Based on an approach used in a previous study,[32] we used two increasingly larger spatial unit definitions. The smaller, more proximal definition was operationalized using sociological neighbourhoods (SNs). These are community-defined spatial units, created in 2008 stemming from a collaborative project between Montreal's Public Health Department and local community

organizations. SN boundaries were defined based on the shared perceptions of residents regarding neighbourhood history, sense of belonging, infrastructure and services, and population characteristics. A total of 111 SNs (mean area=4.5km^2) were designated for the Island of Montreal and have been used to plan and implement local-level initiatives.[33]

Larger spatial units were operationalized using Health and Social Services Centre areas (CSSSs). These are administrative units that bring together several partners including service organizations, health practitioners, pharmacies, private and community organizations, and multi-sectoral organizations.[34] There were 12 CSSS (mean area = 41.7 km^2) territories on the Island of Montreal at the time of data collection. The 111 SNs on the Island of Montreal are nested within the 12 CSSSs territories. Maps of these territories can be found elsewhere.[35]

Residential Environment Features

Three residential environment features were examined. Presence and density of tobacco retail outlets were measured using the 2011 DMTI Enhanced Points of Interest Database ©,[36] a widely-used source that provides geocoded address points for a variety of land uses including tobacco retail.

Tobacco retail outlet counts were obtained at the dissemination area (DA) level, the smallest census unit in Canada.[37] There are 3175 DAs on the Island of Montreal (mean area=0.16 km^2). Density of tobacco retail for each DA was calculated by dividing store counts by the area of the DA in km^2. Presence of tobacco retail outlets was operationalized as a dichotomous variable: DAs with at least one outlet were coded "1" whereas all other DAs were coded "0".

Presence of smoker accommodation facilities was measured using the ISIS observational database.[38] Data collection was performed by trained observers between June and September 2012, using an observation grid. A validation study showed that approximately 75% of the indicators included in this instrument were measured with acceptable to excellent reliability.[39] A total of 1,399 street sections (a portion of street between two intersections, measuring more than 60m in length) based on the residential addresses of respondents and representing unique DAs were audited. Sections with at least one smoking accommodating feature (ashtrays at the entrance of

retail stores, institutions, and community organizations, or in terraces/patios in bars and restaurants) were coded "1" to indicate presence of these facilities, whereas all other street sections were coded "0".

Following data extraction, mean values for all indicators were aggregated to the two spatial units used in this study. Then, to contrast units with the highest values to all other units, mean values were recoded into dichotomous variables, for all indicators. Spatial units at which the highest means were observed (the top tertile) were coded "1" to reflect higher presence, whereas all other units were coded "0". Sensitivity analyses with alternative operationalizations (median split and top quartile) were conducted to assess the robustness of results.

Outcome measure

The outcome measure used in this paper was smoking behaviour patterns. To construct this measure, the first step was to assess participants' smoking status at baseline (T1) and follow-up (T2) based on responses to the following ISIS survey question: "Currently, do you smoke cigarettes every day, occasionally, or never?". Those who responded "never", were classified as non-smokers, whereas those who responded "every day" or "occasionally" were classified as smokers, in line with Health Canada's Canadian Community Health Survey definitions.[40] Following this step participants were classified into two cohorts based their smoking status at baseline. A first cohort compared cessation to maintenance of smoking: 1) participants who reported being smokers both at T1 and T2 were categorized as persistent smokers (smokers for 2 years or longer), whereas those who were smokers at T1 and reported a non-smoker status at T2 were categorized as quitters (non-smokers for fewer than 2 years). A second cohort compared initiation to non-smoking maintenance: 1) participants who were non-smokers at T1 and reported a smoker status at T2 were categorized as initiators (smokers for fewer than 2 years), whereas those who reported being non-smokers both at T1 and T2 were categorized as never smokers (non-smokers for 2 years or longer).

Covariates

Four individual-level covariates were used in analyses: age, sex, educational attainment, and daily smoking at baseline. To facilitate comparisons between groups, age was operationalized as

a dichotomous variable: participants aged 20 to 23 years old were coded "0", whereas older participants (i.e., 24 to 28 years) were coded "1". Male participants were coded "0", whereas female participants were coded "1". Educational attainment was measured at baseline and operationalized as a dichotomous variable. Participants who had already obtained a post-secondary diploma or were enrolled in post-secondary studies at baseline were coded "1", whereas those who completed high school or had a lower degree and were not enrolled in post-secondary studies at baseline were coded "0". Daily smokers at baseline were coded '1', whereas all other were coded '0'.

Area-level material deprivation, both at the SN and CSSS scale, was included as a covariate in fully-adjusted models. This variable was operationalized using a validated index based on census data[41] and measured as a continuous variable, centered around the mean score for the province of Quebec. This index is composed of three indicators: income, education (proportion of persons who have no high-school diploma), and work status (ratio of employment to population).

Statistical Analyses

Descriptive analyses were performed for all variables. Associations between residential environment features and smoking behaviour patterns were examined using random-intercept multilevel logistic models. A "step-up" approach[42] was employed, progressively specifying increasingly complex models. No weights were applied.

Variability in smoking behaviour patterns at each of the two spatial units was assessed through intercept-only models where only the dependent variable is modeled with no predictors at any level. Then, models-with individual-level predictors were built followed by univariate models using each of the features at both the SN and CSSS levels as separate predictors. Finally, models adjusted for the above-described covariates were constructed using the environmental-level features found to be significantly associated with smoking status in the previous step as predictors. Analyses were conducted using HLM v.7 software.[43]

RESULTS

Table 1 provides descriptive information about the sample. Slightly more than half of the sample was aged 20-23 years old (56.5%). Approximately 59% of participants were female. The majority (84.3%) had completed or were pursuing post-secondary studies at baseline. Most young adults did not change their smoking status between baseline and follow-up: 841 (75.4%) remained non-smokers whereas 150 (13.4%) remained smokers. Baseline smoking rates by sex were in line with national survey data.[44] Among those who smoked at baseline, 59 (5.3%) reported a non-smoking status at follow up whereas 61 (5.5%) who were non-smokers at baseline reported being smokers at follow-up. 90 participants (8.1%) were daily smokers at baseline.

Table 1. Descriptive statistics for 1116 young adults from the ISIS cohort (Montreal, Canada, 2014)

	Full Analytical Sample	Never Smoker (Smoker ≥ 2 years)	Quitter (Non-Smoker < 2 years)	Initiator (Smoker < 2 years)	Never Smoker (Non-Smoker ≥ 2 years)
Individual-Level Characteristics					
Age at T2					
20-23 yrs, n (%)	631 (56.5)	82 (13.1)	35 (5.6)	37 (5.9)	473 (75.4)
24-28 yrs, n (%)	485 (43.5)	68 (14.0)	24 (5.0)	24 (5.0)	368 (76.0)
Sex					
Male, n (%)	462 (41.4)	73 (15.9)	27 (5.9)	24 (5.2)	334 (72.9)
Female, n (%)	654 (58.6)	77 (11.8)	32 (4.9)	37 (5.7)	507 (77.6)
Education at Baseline					
High School or lower, n (%)	170 (15.2)	25 (14.8)	11 (6.5)	5 (3.0)	128 (75.7)
Post-secondary or higher, n (%)	941 (84.3)	123 (13.1)	46 (4.9)	56 (6.0)	712 (76.0)
Missing data, n (%)	5 (0.4)				
Smoking Behaviour Pattern					
Persistent Smoker (Smoker ≥ 2 years), n (%)	150 (13.4)				
Quitter (Non-Smoker < 2 years), n (%)	59 (5.3)				
Initiator (Smoker < 2 years), n (%)	61 (5.5)				
Never Smoker (Non-Smoker ≥ 2 years), n (%)	841 (75.4)				
Missing data n (%)	5 (0.4)				
Daily Smoker at Baseline					
Yes, n (%)	90 (8.1)				
No, n (%)	1022 (91.6)				
Missing data n (%)	4 (0.3)				

Table 2 provides descriptive information about residential environment features. Tobacco retail outlets were present in 43.5% of street sections, with a mean density of 10.9/km^2. Smoking accommodation facilities were present in 24.7% of sections. The mean material deprivation index was slightly below zero both at the SN and CSSS level, indicating a relatively lower material deprivation level compared to the mean in the province of Quebec.

Table 2. Descriptive statistics for environmental features measured at the street section level for 1116 young adults from the ISIS cohort (Montreal, Canada, 2014)

Presence of Tobacco Retail Outlets*	
No presence, n (%)	631 (56.5)
Presence, n (%)	485 (43.5)
Density of Tobacco Retail Outlets per km2*	
Mean (SD)	10.9 (20.8)
Presence of Smoking Accommodation Facilities*	
No presence, n (%)	836 (74.9)
Presence, n (%)	276 (24.7)
Missing data, n (%)	4 (0.4)
Material Deprivation Index - SN-Level	
Mean (SD)	-0.014 (0.036)
Range	(-0.108; 0.093)
Material Deprivation Index - CSSS-Level	
Mean (SD)	-0.026 (0.022)
Range	(-0.037; 0.051)

* Presence of tobacco retail outlets was weakly correlated with presence of smoker accommodation at the SN level (r=0.25), whereas density of tobacco retail outlets was not correlated with the other two features at any level. Presence of tobacco retail outlets was perfectly correlated with presence of smoker accommodation at the CSSS level, however the latter was not included in multivariate models

Table 3 shows results for univariate three-level models. No individual-level variables (age, sex, and educational attainment) were associated with smoking behaviour patterns. Of note, models using age as a continuous variable as predictor also showed no significant associations (results not shown).

Models for the baseline smokers' cohort using residential environment features as predictors revealed associations at the local level. Individuals residing in SNs with a higher presence of tobacco retail were less likely to have quit smoking (i.e.: to be non-smokers for fewer than 2 years) (OR=0.42; 95% CI: 0.19, 0.94) compared to participants residing in SNs with a lower presence of this feature. No associations were observed in the non-smoker cohort, and no associations between smoking behaviour patterns and other environmental features were detected at either areal level.

Table 3. Results of logistic 3-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014)

Models for Baseline Smoker Cohort		Models for Baseline Non-Smoker Cohort	
	Smokers at T1		Non-Smokers at T1
	Odds Ratio (95% CI)		Odds Ratio (95% CI)
Age (ref. 20-23 yrs)		**Age (ref. 20-23 yrs)**	
Quitter (Non-Smoker < 2 years)	0 82 (0 43-1 54)	Initiator (Smoker < 2 years)	0 81 (0 49-1 35)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
Sex (ref. male)		**Sex (ref. male)**	
Quitter (Non-Smoker < 2 years)	1 16 (0 62-2 17)	Initiator (Smoker < 2 years)	1 01 (0 61-1 67)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
Education (ref. completed high school or lower)		**Education (ref. completed high school or lower)**	
Quitter (Non-Smoker < 2 years)	0 85 (0 38-1 92)	Initiator (Smoker < 2 years)	2 04 (0 84-4 93)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
SN-Level Presence of Tobacco Retail Stores (ref. low presence)		**SN-Level Presence of Tobacco Retail Stores (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 42 (0 19-0 94)	Initiator (Smoker < 2 years)	0 78 (0 42-1 44)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
SN-Level Density of Tobacco Retail Stores (ref. low density)		**SN-Level Density of Tobacco Retail Stores (ref. low density)**	
Quitter (Non-Smoker < 2 years)	0 60 (0 29-1 26)	Initiator (Smoker < 2 years)	0 94 (0 52-1 72)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
SN-Level Presence of Smoking Accommodation Facilities (ref. low presence)		**SN-Level Presence of Smoking Accommodation Facilities (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 52 (0 25-1 11)	Initiator (Smoker < 2 years)	1 54 (0 90-2 62)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
CSSS-Level Presence of Tobacco Retail Stores (ref. low presence)		**CSSS-Level Presence of Tobacco Retail Stores (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 57 (0 21-1 60)	Initiator (Smoker < 2 years)	1 06 (0 57-1 96)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
CSSS-Level Density of Tobacco Retail Stores (ref. low density)		**CSSS-Level Density of Tobacco Retail Stores (ref. low density)**	
Quitter (Non-Smoker < 2 years)	0 62 (0 24-1 63)	Initiator (Smoker < 2 years)	1 25 (0 68-2 30)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
CSSS-Level Presence of Smoking Accommodation Facilities (ref. low presence)		**CSSS-Level Presence of Smoking Accommodation Facilities (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 81 (0 29-2 27)	Initiator (Smoker < 2 years)	0 87 (0 46-1 65)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref

Table 4 shows results for univariate two-level models. Results were similar to those from three-level models: individuals in the smokers' cohort residing in SNs with a higher presence of tobacco retail were less likely to have quit smoking (i.e.: to be non-smokers for fewer than 2 years) (OR=0.43; 95% CI: 0.20, 0.91) compared to participants residing in SNs with a lower presence of this feature. Also, similar to three-level models, no associations were observed in the non-smoker cohort, and no associations between smoking behaviour patterns and other environmental features were detected at either areal level Given these results, a simpler two-level structure was used in fully-adjusted models.

Table 4. Results of logistic 2-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014)

Models for Baseline Smokers Cohort		Models for Baseline Non-Smokers Cohort	
	Smokers at T1		Non-Smokers at T1
	Odds Ratio (95% CI)		Odds Ratio (95% CI)
SN-Level Presence of Tobacco Retail Stores (ref. low presence)		**SN-Level Presence of Tobacco Retail Stores (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 43 (0 20-0 91)	Initiator (Smoker < 2 years)	0 79 (0 43-1 46)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
SN-Level Density of Tobacco Retail Stores (ref. low density)		**SN-Level Density of Tobacco Retail Stores (ref. low density)**	
Quitter (Non-Smoker < 2 years)	0 69 (0 36-1 32)	Initiator (Smoker < 2 years)	0 95 (0 53-1 71)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref
SN-Level Presence of Smoking Accommodation Facilities (ref. low presence)		**SN-Level Presence of Smoking Accommodation Facilities (ref. low presence)**	
Quitter (Non-Smoker < 2 years)	0 60 (0 30-1 22)	Initiator (Smoker < 2 years)	1 53 (0 90-2 61)
Persistent Smoker (Smoker ≥ 2 years)	ref	Never Smoker (Non-Smoker ≥ 2 years)	ref

Table 5 shows results of fully-adjusted models including individual and areal-level covariates and local-level presence of tobacco retail as predictors. Associations between a higher SN-level presence of tobacco retail and a lower likelihood of quitting (i.e.: of being a non-smoker for fewer than 2 years) remained significant (OR=0.41; 95% CI: 0.19, 0.91). Sensitivity analyses using alternative operationalizations of this variable showed a robust association between these two variables (see Supplementary Tables for details).

Table 5. Results of fully-adjusted logistic 2-level regression models predicting smoking behaviour patterns over 2 years among 1106 young adults from the ISIS cohort (Montreal, Canada, 2014)

	Smokers at T1
	Odds Ratio (95% CI)
SN-Level Presence of Tobacco Retail Stores (ref. low presence)	
Quitter (Non-Smoker < 2 years)	0.41 (0.19-0.91)
Persistent Smoker (Smoker ≥ 2 years)	ref

* Models adjusted for age, sex, education, daily smoking status at baseline, and area-level material deprivation

DISCUSSION

This paper examined scale-specific associations between three residential environment features and smoking behaviour patterns in a cohort of young adults. Results showed that baseline smokers who resided in the same area at follow-up and lived in local-level units (SNs) with a higher presence of tobacco retail stores had a lower likelihood of being quitters, that is, to be non-smokers for fewer than two years, compared to persistent smokers residing in SNs with a lower presence of this feature. The absence of significant associations at larger spatial units (CSSSs) suggests a scale-specific association. These findings are in line with our hypothesis proposing stronger associations between presence of tobacco retail stores and smoking behaviour patterns at a more local scale.

To date the literature examining the potential influence of tobacco retail stores on smoking behaviour remains inconsistent. Whereas some studies have shown a greater likelihood of being a smoker[45] and a lower likelihood of cessation[46 47] in areas with a greater presence of tobacco outlets, others showed no associations.[9 21 48] Similarly, although many showed associations between a higher density of tobacco retail and smoking outcomes,[9 12 21 48 49] other studies did not.[47 50]

A potential reason behind these inconsistencies may be that these findings point to specific dynamics linking tobacco retail availability to different smoking behaviour patterns. To illustrate this point, two areas with the same smoking rates but different underlying dynamics can be imagined (e.g. in Area 1, 80% are persistent smokers and 20% have initiated smoking in the last year, whereas in Area 2, 20% are persistent smokers and 80% are new smokers). In this scenario, features relevant to persistent smokers (Area 1) may be different and not necessarily relevant to initiators (Area 2).

Aside from differences in putative mechanisms, empirical inconsistencies may also be related to the spatial scales used in analyses. For example, whereas two studies examining proximity to tobacco stores in terms of walking distance to the nearest outlet[49] or travel time by car to the nearest store[50] showed no associations with smoking cessation, others using 250m/500m circular buffers did.[46 47 51]

Several mechanisms by which a higher presence of tobacco stores may influence smoking maintenance have been proposed in the literature. In general terms, these provide additional opportunities to obtain tobacco products[5 52] and reduce distance-related search costs,[53-55] therefore facilitating tobacco use. A higher tobacco retail presence may foster a more competitive local market, which in turn may result in lower prices,[21] ultimately translating into higher smoking maintenance rates. Furthermore, the mere sight of these stores may trigger cravings and impulse purchases,[56 57] perhaps even more so for light smokers due to their higher likelihood towards shifts in cravings.[57] Of note, to date no jurisdiction in Canada has enacted restrictions related to tobacco retail location or outlet caps, an approach taken in some cities in the US.[58]

Also, as shown in different systematic reviews,[59-61] point-of-sale marketing (POSM) in tobacco retail outlets, including cigarette price boards announcing promotions[62] (although visible displays and advertising are banned across Canada, featured pricing is permitted in all jurisdictions[58]) increases the likelihood of moving to regular smoking among children, adolescents, and adults. Young adults may be particularly labile to retail marketing tactics,[63] as POSM tends to target stores with higher youth traffic.[64] Furthermore, a higher presence of this feature may contribute to perceptions of smoking as socially acceptable in areas with high outlet presence,[12 21] encouraging tobacco consumption.

We did not find associations between the studied features and an initiator pattern (i.e.: being a smoker for fewer than 2 years). A potential explanation is that exposure to these features may be insufficient to influence this behaviour. Supporting this hypothesis, a study in Canadian young adults,[3] which included indicators of smoking tolerance in and around corner stores and restaurants, showed no associations between these variables and smoking initiation.

Finally, and contrary to our hypothesis, we did not observe any associations between a higher presence of smoker accommodation facilities and smoking behaviour patterns at either scale. Whereas in general terms this can be explained by the reasons outlined above, these findings contrast with those from a previous study of this cohort.[32] One important difference between these two analyses is that in the current study we examined smoking behaviour patterns prospectively, in participants two years older than in our previous study, whereas in the previous investigation we examined this variable retrospectively.

Our study has several strengths. Acknowledging the variable nature of smoking behaviour among young adults, our examination of smoking patterns provides information regarding feature-specific dynamics underlying maintenance of smoking over two years in this group, a relatively under-studied population with the highest smoking prevalence in Canada. Furthermore, we used a prospective design which is likely to have more valid measurements, therefore reducing misclassification bias, and providing a stronger basis for inference. Finally, we examined residential environment features at two different spatial scales, providing information about scale-specific associations between these features and smoking behaviour patterns in this population.

Certain limitations should be acknowledged. First, due to the response rate to the baseline individual questionnaire, there is potential for selection bias. Second, despite a high retention rate, non-responders at follow-up were more likely to be male, less educated, and to be smokers. These two issues may limit the generalizability of findings and may have affected our ability to detect associations. Third, the relatively low number of participants for the initiator category may have reduced our ability to detect associations for the non-smoker cohort. Finally, despite their relevance to exploring scale-specific associations, other spatial scales may be used to study associations between the three features and smoking behaviour patterns. For example, as shown in a recent study of tobacco retail availability and risk of relapse,[21] individual-level availability may influence smoking through mechanisms different to those of neighbourhood-level concentration. Future investigations may want to examine these mechanisms.

CONCLUSIONS

This study contributes to the literature on smoking in young adults. It provides important information regarding the potential influence of a higher presence of tobacco retail on smoking maintenance in this age group. Further research on residential environments and smoking behaviour patterns at different spatial scales is needed to advance knowledge in this area, and to ultimately orient policy and intervention seeking to curb smoking at the local level.

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REFERENCES

1. World Health Organization. WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. Geneva, Switzerland, 2017.

2. Reid JL, Hammond D, Rynard VL, et al. Tobacco Use in Canada: Patterns and Trends. 2015 Edition. Propel Centre for Population Health Impact. Waterloo, Canada, 2015.

3. O'Loughlin JL, Dugas EN, O'Loughlin EK, et al. Incidence and determinants of cigarette smoking initiation in young adults. J Adolesc Health 2014;54(1):26-32 e4. doi: 10.1016/j.jadohealth.2013.07.009

4. Barnett R, Moon G, Pearce J, et al. Smoking Geographies: Space, Place and Tobacco. West Sussex, UK: Wiley Blackwell 2017.

5. Pearce J, Barnett R, Moon G. Sociospatial inequalities in health-related behaviours: Pathways linking place and smoking. Progress in Human Geography 2012;36(1):3-24.

6. Algren MH, Bak CK, Berg-Beckhoff G, et al. Health-Risk Behaviour in Deprived Neighbourhoods Compared with Non-Deprived Neighbourhoods: A Systematic Literature Review of Quantitative Observational Studies. PLoS One 2015;10(10):e0139297. doi: 10.1371/journal.pone.0139297

7. Hammond D. Smoking behaviour among young adults: beyond youth prevention. Tob Control 2005;14(3):181-5. doi: 10.1136/tc.2004.009621

8. Lantz PM. Smoking on the rise among young adults: implications for research and policy. Tob Control 2003;12(S1):i60-i70.

9. McCarthy WJ, Mistry R, Lu Y, et al. Density of tobacco retailers near schools: effects on tobacco use among students. Am J Public Health 2009;99(11):2006-13. doi: 10.2105/AJPH.2008.145128

10. Diez Roux AV, Mair C. Neighborhoods and health. Ann N Y Acad Sci 2010;1186:125-45. doi: 10.1111/j.1749-6632.2009.05333.x

11. Diez Roux AV. Neighborhoods and health: where are we and where do we go from here? Rev Epidemiol Sante Publique 2007;55(1):13-21. doi: 10.1016/j.respe.2006.12.003

12. Pearce J, Rind E, Shortt N, et al. Tobacco Retail Environments and Social Inequalities in Individual-Level Smoking and Cessation Among Scottish Adults. Nicotine Tob Res 2016;18(2):138-46. doi: 10.1093/ntr/ntv089

13. Chan WC, Leatherdale ST. Tobacco retailer density surrounding schools and youth smoking behaviour: a multi-level analysis. Tobacco Induced Diseases 2011;9(9)

14. Marsh L, Ajmal A, McGee R, et al. Tobacco retail outlet density and risk of youth smoking in New Zealand. Tob Control 2015 doi: 10.1136/tobaccocontrol-2015-052512

15. Mennis J, Mason M, Way T, et al. The role of tobacco outlet density in a smoking cessation intervention for urban youth. Health Place 2016;38:39-47. doi: 10.1016/j.healthplace.2015.12.008

16. Burton S, Clark L, Jackson K. The association between seeing retail displays of tobacco and tobacco smoking and purchase: findings from a diary-style survey. Addiction 2012;107(1):169-75. doi: 10.1111/j.1360-0443.2011.03584.x

17. Johns M, Sacks R, Rane M, et al. Exposure to tobacco retail outlets and smoking initiation among New York City adolescents. J Urban Health 2013;90(6):1091-101. doi: 10.1007/s11524-013-9810-2

18. Siahpush M, Shaikh RA, Smith D, et al. The Association of Exposure to Point-of-Sale Tobacco Marketing with Quit Attempt and Quit Success: Results from a Prospective Study of Smokers in the United States. Int J Environ Res Public Health 2016;13(2):203. doi: 10.3390/ijerph13020203

19. Conklin CA, Robin N, Perkins KA, et al. Proximal versus distal cues to smoke: the effects of environments on smokers' cue-reactivity. Exp Clin Psychopharmacol 2008;16(3):207-14. doi: 10.1037/1064-1297.16.3.207

20. Adams ML, Jason LA, Pokorny SB, et al. Exploration of the Link Between Tobacco Retailers in School Neighborhoods and Student Smoking. J Sch Health 2013;83:112-18.

21. Chaiton MO, Mecredy G, Cohen J. Tobacco retail availability and risk of relapse among smokers who make a quit attempt: a population based cohort study. Tob Control 2017(0):1-7. doi: 10.1136/tobaccocontrol-2016-053490

22. Young-Wolff KC, Henriksen L, Delucchi K, et al. Tobacco retailer proximity and density and nicotine dependence among smokers with serious mental illness. Am J Public Health 2014;104:1454-63. doi: 10.2105/AJPH.2014.301917

23. Zhou L, Niu L, Jiang H, et al. Facilitators and Barriers of Smokers' Compliance with Smoking Bans in Public Places: A Systematic Review of Quantitative and Qualitative Literature. Int J Environ Res Public Health 2016;13(1228) doi: doi:10.3390/ijerph13121228

24. Dubray J, Borland T, Chaiton M, et al. Evaluation of the Smoke-Free Ontario Act Outdoor Smoking Regulation. Toronto, ON: Ontario Tobacco Research Unit, 2017.

25. Pederson A, Okoli CT, Hemsing N, et al. Smoking on the margins: a comprehensive analysis of a municipal outdoor smoke-free policy. BMC Public Health 2016;16(852) doi: 10.1186/s12889-016-3466-2

26. Riva M, Gauvin L, Barnett TA. Toward the next generation of research into small area effects on health: a synthesis of multilevel investigations published since July 1998. J Epidemiol Community Health 2007;61(10):853-61. doi: 10.1136/jech.2006.050740

27. Arcaya MC, Tucker-Seeley RD, Kim R, et al. Research on neighborhood effects on health in the United States: A systematic review of study characteristics. Soc Sci Med 2016;168:16-29. doi: 10.1016/j.socscimed.2016.08.047

28. Chaix B, Merlo J, Subramanian SV, et al. Comparison of a spatial perspective with the multilevel analytical approach in neighborhood studies: the case of mental and behavioral disorders due to psychoactive substance use in Malmo, Sweden, 2001. Am J Epidemiol 2005;162(2):171-82. doi: 10.1093/aje/kwi175

29. Boone-Heinonen J, Popkin BM, Song Y, et al. What neighborhood area captures built environment features related to adolescent physical activity? Health Place 2010;16(6):1280-6. doi: 10.1016/j.healthplace.2010.06.015

30. Flowerdew R, Manley DJ, Sabel CE. Neighbourhood effects on health: does it matter where draw the boundaries? Soc Sci Med 2008;66(6):1241-55. doi: 10.1016/j.socscimed.2007.11.042

31. Frohlich KL, Shareck M, Vallee J, et al. Cohort Profile: The Interdisciplinary Study of Inequalities in Smoking (ISIS). Int J Epidemiol 2015 doi: 10.1093/ije/dyv036

32. Ghenadenik AE, Frohlich KL, Gauvin L. Beyond Smoking Prevalence: Exploring the Variability of Associations between Neighborhood Exposures across Two Nested Spatial Units and Two-Year Smoking Trajectory among Young Adults. Int J Environ Res Public Health 2016;13(1) doi: 10.3390/ijerph13010106

33. Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal. Description des découpages territoriaux 2018 [Available from: https://emis.santemontreal.qc.ca/outils/atlas-sante-montreal/cartes-en-pdf/decoupages-territoriaux-pdf/ accessed November 12, 2018.

34. Ministère de la santé et des services sociaux. Système de santé et de services sociaux en bref 2014 [Available from: http://www.msss.gouv.qc.ca/sujets/organisation/en-bref/gouvernance-et-organisation/reseaux-locaux-de-services accessed November 2, 2014.

35. Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal. Les voisinages de Montréal: Gouvernement du Québec; 2018 [Available from: https://emis.santemontreal.qc.ca/fileadmin/emis/Outil/Atlas/carte_pdf/decoupages/voisinage.pdf accessed November 12, 2018.

36. DMTI Spatial Inc. Enhanced Points of Interest v.3. Markham, Canada, 2011.

37. Statistics Canada. 2015 [Available from: https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/index-eng.cfm accessed September 20, 2015.

38. Bernard P, Charafeddine R, Frohlich KL, et al. Health inequalities and place: a theoretical conception of neighbourhood. Soc Sci Med 2007;65(9):1839-52. doi: 10.1016/j.socscimed.2007.05.037

39. Shareck M, Dassa C, Frohlich KL. Improving the measurement of neighbourhood characteristics through systematic observation: inequalities in smoking as a case study. Health Place 2012;18(3):671-82. doi: 10.1016/j.healthplace.2011.11.008

40. Statistics Canada. Canadian Community Health Survey - Annual Component (CCHS) 2014 [Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226 accessed June 3, 2015.

41. Pampalon R, Hamel D, Gamache P, et al. An Area-based Material and Social Deprivation Index for Public Health in Québec and Canada. Can J Public Health 2012;103(S2):S17-S22.

42. Tabachnick BG, Fidell LS. Using Multivariate Statistics. 6th ed. Boston, MA: Pearson Education 2013:786-861.

43. HLM 7.03 [program]. Skokie, IL: Scientific Software International, Inc.

44. Health Canada. Canadian Tobacco Use Monitoring Survey (CTUMS) 2012 2012 [Available from: https://www.canada.ca/en/health-canada/services/publications/healthy-living/canadian-tobacco-use-monitoring-survey-2012-supplementary-tables.html accessed August 30, 2018.

45. Chuang YC, Cubbin C, Ahn D, et al. Effects of neighbourhood socioeconomic status and convenience store concentration on individual level smoking. J Epidemiol Community Health 2005;59(7):568-73. doi: 10.1136/jech.2004.029041

46. Halonen JI, Kivimaki M, Kouvonen A, et al. Proximity to a tobacco store and smoking cessation: a cohort study. Tob Control 2014;23(2):146-51. doi: 10.1136/tobaccocontrol-2012-050726

47. Reitzel LR, Cromley EK, Li Y, et al. The effect of tobacco outlet density and proximity on smoking cessation. Am J Public Health 2011;101(2):315-20. doi: 10.2105/AJPH.2010.191676

48. Shareck M, Kestens Y, Vallee J, et al. The added value of accounting for activity space when examining the association between tobacco retailer availability and smoking among young adults. Tob Control 2015 doi: 10.1136/tobaccocontrol-2014-052194

49. Cantrell J, Anesetti-Rothermel A, Pearson JL, et al. The impact of the tobacco retail outlet environment on adult cessation and differences by neighborhood poverty. Addiction 2015;110(1):152-61. doi: 10.1111/add.12718

50. Pearce J, Hiscock R, Moon G, et al. The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour. J Epidemiol Community Health 2009;63(1):69-77. doi: 10.1136/jech.2007.070656

51. Chaiton M, Mecredy G, Rehm J, et al. Tobacco retail availability and smoking behaviours among patients seeking treatment at a nicotine dependence treatment clinic. Tob Induc Dis 2014;12(1):19. doi: 10.1186/1617-9625-12-19

52. Paul CL, Mee KJ, Judd TM, et al. Anywhere, anytime: retail access to tobacco in New South Wales and its potential impact on consumption and quitting. Soc Sci Med 2010;71(4):799-806. doi: 10.1016/j.socscimed.2010.05.011

53. Schneider JE, Reid RJ, Peterson NA, et al. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. Prev Sci 2005;6(4):319-25. doi: 10.1007/s11121-005-0016-z

54. Scully M, McCarthy M, Zacher M, et al. Density of tobacco retail outlets near schools and smoking behaviour among secondary school students. Australian and New Zealand Journal of Public Health 2013;37(6):574-78. doi: 10.1111/1753-6405.12147

55. Siahpush M, Jones PR, Singh GK, et al. Association of availability of tobacco products with socio-economic and racial/ethnic characteristics of neighbourhoods. Public Health 2010;124(9):525-9. doi: 10.1016/j.puhe.2010.04.010

56. Burton S, Hoek J, Nesbit P, et al. "Smoking is bad, it's not cool…yet I'm still doing it": Cues for tobacco consumption in a 'dark' market. Journal of Business Research 2015;68(10):2067-74. doi: 10.1016/j.jbusres.2015.03.004

57. Kirchner TR, Cantrell J, Anesetti-Rothermel A, et al. Geospatial exposure to point-of-sale tobacco: real-time craving and smoking-cessation outcomes. Am J Prev Med 2013;45(4):379-85. doi: 10.1016/j.amepre.2013.05.016

58. Canadian Cancer Society. Overview Summary of Federal/Provincial/Territorial Tobacco Control Legislation in Canada, 2017:123.

59. Robertson L, McGee R, Marsh L, et al. A systematic review on the impact of point-of-sale tobacco promotion on smoking. Nicotine Tob Res 2015;17(1):2-17. doi: 10.1093/ntr/ntu168

60. Lovato C, Watts A, Stead LF. Impact of tobacco advertising and promotion on increasing adolescent smoking behaviours. Cochrane Database of Systematic Reviews 2011(10) doi: 10.1002/14651858.CD003439.pub2.

61. Paynter J, Edwards R. The impact of tobacco promotion at the point of sale: a systematic review. Nicotine Tob Res 2009;11(1):25-35. doi: 10.1093/ntr/ntn002

62. Burton S, Spanjaard D, Hoek J. An investigation of tobacco retail outlets as a cue for smoking. Australasian Marketing Journal (AMJ) 2013;21(4):234-39. doi: 10.1016/j.ausmj.2013.08.003

63. Shadel WG, Martino SC, Setodji C, et al. Momentary effects of exposure to prosmoking media on college students' future smoking risk. Health Psychology 2012;31(4):460-66. doi: 10.1037/a0027291

64. Frick RG, Klein EG, Ferketich AK, et al. Tobacco advertising and sales practices in licensed retail outlets after the Food and Drug Administration regulations. J Community Health 2012;37(5):963-7. doi: 10.1007/s10900-011-9532-x

Supplementary Table 1. Results of fully-adjusted* logistic 2-level regression models predicting change in smoking status over 2 years among 1106 adults from the ISIS study (Montreal, Canada, 2014) - Residential environment features operationalized using median split

	Smokers at T1
	Odds Ratio (95% CI)
SN-Level Presence of Tobacco Retail Stores (ref. low presence)	
Quitter (Non-Smoker < 2 years)	0.60 (0.31-1.17)
Persistent Smoker (Smoker ≥ 2 years)	ref

* Models adjusted for age, sex, education, daily smoking at baseline and area-level material deprivation

Supplementary Table 2. Results of fully-adjusted* logistic 2-level regression models predicting change in smoking status over 2 years among 1106 adults from the ISIS study (Montreal, Canada, 2014) - Residential environment features operationalized using top quartile vs. all other

	Smokers at T1
	Odds Ratio (95% CI)
SN-Level Presence of Tobacco Retail Stores (ref. low presence)	
Quitter (Non-Smoker < 2 years)	0.37 (0.15-0.93)
Persistent Smoker (Smoker ≥ 2 years)	ref

* Models adjusted for age, sex, education, daily smoking at baseline and area-level material deprivation

Fully-Adjusted Models - SN-Level Tobacco Retail Presence (ref. non-smoker <2 years)*			
	Top Half	**Top Tertile****	**Top Quartile**
High Presence - Quitter (Non-Smoker < 2 years)	0.60 (0.31-1.17)	0.41 (0.19-0.91)	0.37 (0.15-0.93)

* Models adjusted for age, sex, education, daily smoking at baseline and area-level material deprivation

** Measure used in the main analyses

ARTICLE 3

Title Smoking behaviour in young adults: A study of 4-year smoking patterns and residential presence of features facilitating smoking using data from the *Interdisciplinary Study of Inequalities in Smoking* cohort

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ABSTRACT

Introduction: Young adults have the highest prevalence of smoking among all age groups in most industrialized countries and exhibit great variability in smoking behaviour. Availability of tobacco products and smoker accommodation facilities have been found to be associated with smoking prevalence and cessation rates, however little is known about their potential to influence specific patterns including maintenance and changes in smoking status over time.

Methods: Based on data from the Interdisciplinary Study of Inequalities in Smoking cohort of 18-25 year-old Montreal residents (n=1025), we examined associations between 4-year smoking patterns measured at 3 time-points and proximal presence/density of tobacco retail and presence of smoker accommodation facilities in Montreal, Canada. Associations were tested using 2-level multinomial models.

Results: In fully-adjusted models, compared to never smokers, residents of areas with a higher density of tobacco retail were more likely to 1) be characterized as persistent smokers, 2) have experienced repeated changes in smoking status (being "switchers") during the 4-year study period, and 3) be ex-smokers.

Conclusion: Findings show that residential environment features are associated with 4-year smoking patterns in young adults. Specific pairs of patterns-feature associations may point to unique mechanisms by which features could influence smoking behaviour patterns. These findings require replication and extension including testing hypotheses regarding tobacco retail density's role in sustaining smoking and in influencing changes in smoking status.

INTRODUCTION

Despite sustained decreases over the past decades, young adults continue to have the highest prevalence of smoking among all age groups in many industrialized countries including New Zealand, the UK, and Canada.[1-3] Also, whereas in the latter initiation rates between 2001 and 2013 declined in youth (ages 5-17 years), this has not been the case in young adults (ages 18-25 years).[4] Studies indicate that as many as 30% of individuals initiate smoking in young adulthood.[5] These trends have been acknowledged by organizations such as the Institute of Medicine (now National Academy of Medicine), that make smoking prevalence reduction in young adults a priority.[6]

Young adulthood is now recognized as a critical life-period comprised of significant living, social, educational, and occupational changes, within which different health behaviours including smoking may be adopted and/or become established.[6] Smoking behaviour may be particularly variable in this age group, being characterized by pattern shifts comprised of repeated changes in smoking frequency and status,[7] perhaps even more so among light and intermittent smokers (i.e.: typically defined as individuals who smoke 5 or fewer cigarettes/day and non-daily smokers,[8] a behavioural pattern overrepresented in this age group[9]) given their higher susceptibility to cue-triggered smoking.[10] An example of this variability can be evidenced in a 2004 cohort study of US college students.[11] At follow-up after 4 years, 13% of daily smokers at baseline had quit smoking whereas 28% became occasional smokers, 14% of occasional smokers had become daily smokers while 51% quit smoking, and 11% of non-smokers initiated smoking. Adding further to this variability, unstable smoking patterns and mixed smoking trajectories (e.g.: quitting or reducing and then relapsing to a level higher than baseline or increasing and then decreasing to baseline or lower levels of smoking) are more likely among young adults.[12-15] These results underscore the need for the specific examination of change patterns,[7] as they may point to potential future changes in smoking behaviour regardless of smoking status at any given time, and may be helpful in identifying young adults most vulnerable to becoming established smokers.

Smoking outcomes including prevalence and cessation rates have been found to be associated with contextual-level factors in proximity to people's homes.[16] Among these, presence and density of tobacco retail and presence of smoker accommodation facilities (e.g., outdoor patios/terraces) have been highlighted as relevant targets for public health action towards smoking prevalence reduction.[17] [18] However, few studies have examined the potential influence of these features on

different smoking behaviour patterns.[19] Moreover, although limited, there is evidence suggesting that specific residential environment features may influence distinct behavioural patterns. For example, whereas two studies of smoking initiation and maintenance in adolescents showed associations between a higher density of tobacco retail around homes and schools and smoking initiation, no associations with smoking maintenance were detected.[20 21]

Even less is known in terms of the potential influence of the presence or density of tobacco retail on variable smoking patterns: to the best of our knowledge no studies to date have examined these associations. Nonetheless, potential mechanisms described in the literature suggest that these features have the potential to exacerbate variable patterns comprised of repeated switches between being a smoker and a non-smoker. These include an increased availability of tobacco products,[22] reduced search costs,[23] lower prices resulting from increased local competition[24] environmental cues,[25] and point-of-sale marketing (POSM) tactics including in-store advertising, pack displays, and price promotions.[25] These mechanisms may contribute to amplifying switching patterns by triggering cravings and impulse purchases of tobacco products.[25-27]

Associations between smoking maintenance and presence of smoker accommodation facilities have also been reported in some studies, suggesting a potential role of this feature as smoking-supporting structures. For instance, a Canadian study examining a cohort of smokers reported a higher likelihood of relapse among quitters exposed to outdoor patio/terrace smoking,[28] whereas a previous analysis based on this study's cohort revealed that young adults residing in areas with a higher presence of these features were more likely to be smokers for 2 years or longer compared to never smokers.[29]

The paucity of studies acknowledging different young adult smoking behaviour patterns and examining their association with residential-level smoking-related features points to the need for additional knowledge in this area. This study contributes to the literature by examining smoking behaviour patterns in young adults over a 4-year period and their association with two residential features namely, presence and density of tobacco retail and presence of smoker accommodation facilities.

We hypothesized that: 1) young adults residing in areas with presence of and/or a higher density of tobacco retail would be more likely to have changed their smoking status at least twice over the course of 4 years, and 2) to be persistent smokers, whereas 3) those residing in areas with presence of smoker accommodation facilities would be more likely to be persistent smokers.

METHODS

Sampling

The Interdisciplinary Study of Inequalities in Smoking (ISIS) cohort was the main data source for this paper. ISIS main objective is to examine the interactive role of individual and contextual factors in the production of social inequalities in smoking among young adults living in Montreal.[30] Participants were initially recruited based on a random sample of 6,020 non-institutionalized individuals aged 18 to 25 years who had resided at the same address for at least one year. Names and addresses were provided by the Régie de l'Assurance Maladie du Québec, Quebec's universal health insurance programme. Prospective participants were sent an invitation letter. Upon acceptance, 2,093 individuals completed an online questionnaire between November 2011 and September 2012. Other response methods were made available upon request. The final response rate was 37.6%. These rates are typical in observational studies and may be due to unreported moves, inaccurate mailing addresses, or lack of interest in participating. The sample had similar characteristics to respondents from the Canadian Community Health Survey (CCHS) in terms of age and sex, although a larger proportion of participants reported more a higher educational attainment and poorer physical/mental health.[30] Follow-up took place two years after cohort inception. Participants were contacted via e-mail, telephone, and letter reminders. A total of 1,457 individuals were retained at follow-up (73.3%). Information regarding sampling and survey details is available elsewhere.[30] Analyses were restricted to participants residing in the same area at baseline and follow up and for who complete data were available (n=1025). The ISIS study was approved by the Research Ethics Committee of the Université de Montréal's Faculty of Medicine. All participants provided informed consent.

Tobacco retail presence and density

The 2011 DMTI Enhanced Points of Interest Database,[31] which provides geocoded address points for a variety of land uses including stores where tobacco products are usually sold was used to measure presence and density of tobacco retail. The validity of this source was assessed using

the 2010 version of the EPOI© database. Sensitivity values were 0.75 for convenience stores and 0.92 for supermarkets whereas positive predictive values were 0.75 and 1.00 for each store type respectively.[32] Dissemination areas (DAs),[33] the smallest census units used in Canada, were used as spatial proxies for proximal-level presence/density of this feature. Data were geocoded using ArcGIS© v.10.4 at the DA level. There were 3175 DAs on the Island of Montreal (mean area=0.16 km^2) at the time of data collection. For modeling purposes, DAs with at least one tobacco retail outlet were coded "1" whereas all others were coded "0". Tobacco retail density was computed by dividing store counts by the area of each DA in km^2. Then, for contrast purposes, DAs for which the highest values were observed (top quartile) were coded "1" to reflect higher density, whereas all others were coded "0". Alternative operationalizations of this variable (top tertile, top quintile) were used in sensitivity analyses.

Smoker accommodation facilities

This feature was measured using the ISIS observational database which comprises 86 indicators of different residential environment characteristics. Trained observers used a validated observation grid[34] to collect data between June and September 2012. A validation study of this instrument showed that approximately 75% of indicators were measured with acceptable to excellent reliability.[34] A total of 1,399 street sections (a portion of street between two intersections, measuring more than 60m in length) representing unique DAs where participants resided were audited. Sections with at least one feature present (i.e., ashtrays at the entrance of retail stores, institutions, and community organizations, or in terraces/patios in bars and restaurants) were coded "1", whereas all others were coded "0".

Smoking Patterns

Smoking patterns were measured based on self-reported smoking behaviour at three time points: two years prior to baseline, at baseline, and at follow-up two years later. Two-year intervals were chosen based on evidence regarding milestones of nicotine dependence and smoking cessation.[35] Both daily and occasional smokers were classified as smokers, consistent with Health Canada's definitions.[36] Participants were classified into five categories: 1) those who were smokers at all time points were classified as "persistent smokers", 2) participants who were either a) non-smokers both at baseline and follow-up but were smokers prior to baseline or b) non-smokers for fewer than two years at baseline and were non-smokers at follow-up were classified as "ex-smokers", 3) those

who were either a) smokers for fewer than 2 years at baseline and were smokers at follow-up or b) non-smokers for 2 years or longer at baseline but were smokers at follow-up were classified as "new smokers", 4) participants who changed their smoker status (either from smoker to non-smoker or vice versa) both at baseline and follow-up were classified as "switchers", and 5) those who were not smokers at any time point were classified as "never smokers".

Covariates

Age, sex, and education were included as covariates in fully-adjusted models. Age was dichotomized for contrast purposes between 20-23 years old (coded "0") and 24-28 years old (coded "1"). Male participants were coded "0", whereas female participants were coded "1". Education was measured at baseline, based on participants' highest level attained at the time of survey, or expected to be attained. This approach was found to offer a good approximation of future educational achievement.[37] Since differences in smoking rates were most marked between individuals having attained post-secondary studies and all other participants, this variable was also dichotomized for contrast purposes. Participants who had completed or were enrolled in post-secondary studies were coded "1", whereas those who did not were coded "0".

DA-level material deprivation was also included as a covariate in fully adjusted models. This variable was operationalized using Pampalon's material deprivation index[38] measured in quartiles centered around the mean score for the province of Quebec. This measure comprises three indicators: mean income, education (proportion of persons who have no high-school diploma), and ratio of employment to population. DAs with scores in the highest quartile were categorized as "most deprived" (coded "1"), whereas all other DAs were coded "0".

Statistical Analyses

Prior to modeling, descriptive analyses were performed for all variables. A "step-up" approach[39] was used for modeling purposes. Associations between DA-level features and smoking patterns were tested using random-intercepts two-level multinomial models (Level 1: individuals, Level 2: DAs). No weights were applied. A first model using sex, age, and educational attainment as predictors was specified, followed by univariate models using each DA-level feature as predictor. Finally, fully-adjusted models using the features found to be significantly associated with smoking

patterns in the previous step were tested. Descriptive analyses were performed using SPSS v.25.0 software, and multilevel models were developed using HLM v.7.03 software.

RESULTS

Table 1 provides descriptive information about the analytical sample. Slightly over half of participants (52.7%) were aged 20-23 years old at follow-up. Approximately 58% were female. Most had completed or expected to complete post-secondary studies (85.6%) and were never smokers (64.5%). About 13% were persistent smokers, whereas about 14% were ex-smokers. Switchers and new smokers respectively accounted for 4.6% and 4.4% of the analytical sample. Younger participants accounted for higher proportions of switchers and new smokers. Female participants accounted for higher proportions of ex-smokers, new smokers, and never smokers, whereas male participants had a higher proportion of switchers.

The mean area of DAs where participants resided was 0.16 km^2 (median=0.08 km^2, range 0.01-5.55 km^2). Approximately 40% of participants resided in DAs where tobacco retail outlets were present, and about 21% resided in DAs with a presence of smoker accommodation facilities. The mean density of tobacco retail at the DA level was 8.9 stores per km^2. Presence of smoker accommodation facilities was weakly, albeit significantly correlated with presence ($r=0.17$, $p<0.001$) and density ($r=0.14$, $p<0.001$) of tobacco retail stores. Presence and density of tobacco retail stores were moderately correlated ($r=0.62$, $p<0.001$), however they were not simultaneously included in fully-adjusted models.

Table 1. Descriptive statistics for 1025 young adults from the *Interdisciplinary Study of Inequalities in Smoking* (Montreal, Canada, 2014)

	Full Sample	Persistent Smokers	Ex-Smokers	New Smokers	Switchers	Never Smokers	p-value†
Individual-Level Characteristics							
Age at T2							
20-23 yrs, n (%)	540 (52.7)	62 (47.0)	70 (50.0)	32 (71.1)	31 (66.0)	345 (52.2)	0.020*
24-28 yrs, n (%)	485 (47.3)	70 (53.0)	70 (50.0)	13 (28.9)	16 (34.0)	316 (47.8)	
Sex							
Male, n (%)	425 (41.5)	64 (48.5)	55 (39.3)	16 (35.6)	28 (59.6)	262 (39.6)	0.028*
Female, n (%)	600 (58.5)	68 (51.5)	85 (60.7)	29 (64.4)	19 (40.4)	399 (60.4)	
Education at Baseline							
High School or lower, n (%)	148 (14.4)	19 (14.4)	16 (11.4)	9 (20.0)	5 (10.6)	99 (15.0)	0.582
Post-secondary or higher, n (%)	877 (85.6)	113 (85.6)	124 (88.6)	36 (80.0)	42 (89.4)	562 (85.0)	
Smoking Pattern T0-T1-T2							
Persistent Smoker, n (%)	132 (12.9)						
Ex-Smoker, n (%)	140 (13.7)						
New Smoker, n (%)	45 (4.4)						
Switcher, n (%)	47 (4.6)						
Never Smoker, n (%)	661 (64.5)						
Residential Environment Features							
Presence of Tobacco Retail Outlets, n (%)	411 (40.1)	46 (34.8)	55 (39.3)	18 (40.0)	23 (48.9)	269 (40.7)	0.528
Density of Tobacco Retail Outlets per km2, mean (SD)	8.90 (16.51)						
Presence Smoking Accommodation Facilities, n (%)	217 (21.2)	38 (28.8)	24 (17.1)	11 (24.4)	7 (14.9)	137 (20.7)	0.115
DA Area in Km2 by Participant							
Mean	0.16						
Median	0.08						
Range	0.01-5.55						
DA-Level Material Deprivation							
Q1 to Q3, n (%)	769 (75.0)	107 (81.1)	98 (70.0)	33 (73.3)	36 (76.6)	495 (74.9)	0.332
Q4 (highest deprivation), n (%)	256 (25.0)	25 (18.9)	42 (30.0)	12 (26.7)	11 (23.4)	166 (75.1)	

† Pearson's chi-square test, * p-value <0.01, ** p-value <0.05

†† Among switchers, 47 participants were smokers 2 years prior to baseline, non-smokers at baseline and smokers at follow-up, whereas 17 were non-smokers 2 years prior to baseline, smokers at baseline and non-smokers at follow-up

Correlations between features: presence of smoker accommodation facilities/presence of tobacco retail stores: r=0.17 ($p<0.001$); presence of smoker accommodation facilities/density of tobacco retail stores: r=0.14 ($p<0.001$); presence of tobacco retail stores/density of tobacco retail stores: r=0.62 ($p<0.001$)

Table 2 shows results for multilevel models using DA-level features as predictors. Compared to never smokers, young adults residing in DAs with a higher density of tobacco retail stores were more likely to have been switchers over a 4-year period (OR= 2.03; 95% CI: 1.09, 3.81), as well as to have been persistent smokers (OR=1.68; 95% CI: 1.11, 2.55) or ex-smokers (OR= 1.65; 95% CI: 1.10, 2.47). Also, participants residing in DAs with a presence of smoker accommodation facilities were more likely to be persistent smokers (OR= 1.54; 95% CI: 1.01, 2.37).

Table 2. Results of multinomial multilevel regression models predicting smoking patterns over 4 years among 1025 young adults from the *Interdisciplinary Study of Inequalities in Smoking* using DA-level features as predictors (Montreal, Canada, 2014)

	Odds Ratio (95% CI)
DA-Level Presence of Tobacco Retail Stores (ref. low presence)	
Persistent Smoker	0.78 (0.52-1.15)
Ex-Smoker	0.94 (0.65-1.37)
New Smoker	0.97 (0.52-1.81)
Switcher	1.40 (0.77-2.54)
Never Smoker	ref
DA-Level Density of Tobacco Retail Stores (ref. low density)	
Persistent Smoker	1.68 (1.11-2.55)*
Ex-Smoker	1.65 (1.10-2.47)*
New Smoker	0.90 (0.42-1.92)
Switcher	2.03 (1.09-3.81)*
Never Smoker	ref
DA-Level Presence of Smoker Accommodation Facilities (ref. low presence)	
Persistent Smoker	1.54 (1.01-2.37)*
Ex-Smoker	0.79 (0.49-1.28)
New Smoker	1.24 (0.61-2.52)
Switcher	0.67 (0.29-1.54)
Never Smoker	ref

** p-value <0.01, * p-value <0.05

Table 3 shows results of multilevel models using DA-level features as predictors, adjusted by individual and area-level covariates. Associations between density of tobacco retail and smoking patterns remained significant, with relatively little change in odds ratios (see Model 1), whereas the association between presence of smoker accommodation facilities and a persistent smoker pattern was no longer significant (p=0.055; see Model 2). Specifically, compared to never smokers, participants residing in DAs with a higher density of tobacco retail were more likely to have been switchers over a 4-year period (OR= 2.20; 95% CI: 1.16, 4.16), persistent smokers (OR= 1.77; 95% CI: 1.16, 2.71), and ex-smokers (OR= 1.64; 95% CI: 1.09, 2.47). Sensitivity analyses using

alternative operationalizations of tobacco retail density showed a robust association between these two variables (see Supplementary Tables for details).

Table 3. Results of fully-adjusted multinomial multilevel regression models predicting smoking patterns over 4 years among 1025 young adults from the *Interdisciplinary Study of Inequalities in Smoking* (Montreal, Canada, 2014)

	Model 1	**Model 2**
	Odds Ratio (95% CI)	
DA-Level Density of Tobacco Retail Stores (ref. low density)		
Persistent Smoker	1.77 (1.16-2.71)**	-
Ex-Smoker	1.64 (1.09-2.47)*	-
New Smoker	0.87 (0.40-1.87)	-
Switcher	2.20 (1.16-4.16)*	-
Never Smoker	ref	-
DA-Level Presence of Smoker Accommodation Facilities (ref. low presence)		
Persistent Smoker	-	1.52 (0.99-2.35)
Ex-Smoker	-	0.79 (0.49-1.28)
New Smoker	-	1.25 (0.61-2.55)
Switcher	-	0.65 (0.28-1.50)
Never Smoker	-	ref

** p-value <0.01, * p-value <0.05. Models adjusted for age, sex, education and area-level material deprivation

DISCUSSION

We examined associations between 4-year smoking patterns in young adults and residential-This paper examined associations between 4-year smoking patterns in young adults and residential-level presence and density of tobacco retail and presence of smoker accommodation facilities. Three specific patterns were associated with these features. As hypothesized, the likelihood of being a switcher (having changed smoking status at least twice within a 4-year timeframe) and of being a persistent smoker was higher among participants residing in areas with a higher density of tobacco retail. Furthermore, although not initially anticipated, young adults residing in these areas had a higher likelihood of being ex-smokers (i.e.: participants who had reported a non-smoker status at follow-up but who were smokers either two years prior to baseline or both at baseline and two years prior to baseline). These findings highlight the importance of examining smoking behaviour patterns and their independent association with residential characteristics and suggest that residential environment features may play an important role in shaping young adult smoking behaviour across time. Moreover, associations between specific pairs of smoking patterns and

features suggest that distinct characteristics may play different roles in influencing smoking behaviour in this age group.

The association between switcher patterns and a residential-level higher density of tobacco retail underscores this feature's potential to exacerbate variable smoking behaviour patterns in young adults. These results suggest that regardless of their smoking status at a certain time point, this population may continue to experience further switches, potentially leading to established smoking. Indeed, although unexpected, the associations between this feature and ex-smoker patterns found in our analyses may be interpreted as harbingers of future changes in smoking status in this labile population. Potential mechanisms linking this feature to smoking behaviour have been described in the introduction. In general terms, a greater local-level density of tobacco retail may contribute to sustaining smoking among those with a more established pattern, as well as to exacerbate variable smoking patterns via an increased accessibility and availability of tobacco products.[40] Furthermore, pricing may play a significant role in shaping young adult smoking behaviour patterns, since as shown in a 2010 systematic review, this age group is highly sensitive to the price of tobacco products due to lower incomes, peer influence, and higher rates of experimental smoking.[41] This sensitivity may influence switching patterns comprised of bouts of smoking and non-smoking behaviour.

Environmental cues may also contribute to switching by triggering cravings and impulse purchases of tobacco products. These cues include point-of-sale marketing (POSM) tactics such as price boards announcing cigarette promotions, which are well-known to increase the likelihood of smoking,[25] potentially even more so in young adults due to their responsiveness to retail marketing.[42] Of note, although in contrast with the United States and other countries, most forms of POSM are banned across Canada, subtle tactics such as store signs announcing featured pricing are still allowed in all jurisdictions.[43] Also, cues including the mere sight of tobacco-selling stores are known to elicit real-time cravings leading to impulse smoking,[26 27] in particular in light smokers who are more likely to experience shifts in smoking urges.[26] Furthermore, residential proximity to tobacco retail (e.g.: presence of stores within a 500m radius) has been found to be associated with a lower likelihood of making quit attempts and a higher risk of relapse.[24 27]

Persistent smoking patterns were also more likely among young adults residing in areas with a higher density of tobacco retail. The literature highlights several mechanisms by which this feature

may influence smoking maintenance. Aside from providing increased accessibility and opportunities to purchase tobacco products[22 44], a higher density of tobacco retail may lead to lower prices due to a more competitive local market[24] and may contribute to normalize smoking at the local level.[24 45]

Although in univariate models we detected an association between the presence of smoker accommodation facilities and persistent smoking patterns among young adults, results were no longer statistically significant in fully adjusted models (p=0.055). Given that studies suggest that smoker accommodation features may contribute to sustaining smoking by creating spaces where this behaviour is facilitated and where smoking can be a means of socializing and having fun,[46] these results may be due to lack of sufficient power of our analytical sample. Hence, future studies may want to continue examining the potential influence of this feature on young adult smoking behaviour patterns.

A key strength of our study is its acknowledgment and examination of a variety of longer-term smoking behaviour patterns in young adults. These analyses provide additional insights concerning tobacco use in this population and how different behavioural patterns may be influenced by residential environment features. Moreover, its longitudinal design provides a stronger basis for causal inference. Finally, our focus on young adults contributes to a limited literature on place effects on smoking in this population.

Some limitations must also be acknowledged. First, given the response rate to the baseline questionnaire selection bias may have influenced results. Second, despite the high follow-up retention rate, non-responders to be smokers, male, and less educated, therefore potentially limiting the generalizability of findings. Third, although we were specifically interested in features in the residential environment, young adults may have been exposed to these and other features (e.g., new friends who smoke) within other activity spaces (e.g.: work, study, leisure) which in turn could have also influenced smoking behaviour patterns. Furthermore, although the covariates included in fully-adjusted models are among those most significantly associated with smoking behaviour in young adults, there is potential for residual confounding stemming from unmeasured individual and contextual factors. Also, we did not measure alternative tobacco product use and therefore findings only apply to behaviour related to traditional combustible tobacco products. Finally, some

categories of our dependent variable had a relatively low number of participants, which in certain cases may have reduced our ability to detect associations.

CONCLUSION

This study contributes to the sparse literature on smoking in young adults by providing new information on smoking behaviour patterns and their association with residential environmental features. Our findings suggest that a higher density of tobacco retail surrounding residential addresses may help sustain persistent smoking patterns, and may also exacerbate changes in smoking behaviour in this population. Since no restrictions regarding zoning or area caps on the number of tobacco retailers have been enacted to date in Canada,[43] policy regulating the tobacco retail landscape may be a promising avenue to curb smoking at the local level.[47 48]

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Provenance and peer review: Not commissioned; externally peer reviewed.

Data sharing statement: Data are available to bona fide researchers from KLF upon request.

REFERENCES

1. Health Promotion Agency of New Zealand. Smokefree NZ 2016 [Available from: https://www.smokefree.org.nz/smoking-its-effects/facts-figures accessed January 9, 2019.

2. Office for National Statistics. Adult smoking habits in the UK: 2017, 2018.

3. Reid JL, Hammond D, Rynard VL, et al. Tobacco Use in Canada: Patterns and Trends, 2017 Edition. Waterloo, Canada: Propel Centre for Population Health Impact, University of Waterloo, 2017.

4. Gagne T, Veenstra G. Trends in smoking initiation in Canada: Does non-inclusion of young adults in tobacco control strategies represent a missed opportunity? Can J Public Health 2017;108(1):e14-e20. doi: 10.17269/cjph.108.5839

5. Freedman KS, Nelson NM, Feldman LL. Smoking Initiation Among Young Adults in the United States and Canada, 1998-2010: A Systematic Review. Preventing Chronic Disease 2011 doi: 10.5888/pcd9.110037

6. Institute of Medicine and National Research Council. Investing in the health and well-being of young adults. Washington, DC: The National Academies Press 2015.

7. Hammond D. Smoking behaviour among young adults: beyond youth prevention. Tob Control 2005;14(3):181-5. doi: 10.1136/tc.2004.009621

8. Husten CG. How should we define light or intermittent smoking? Does it matter? Nicotine Tob Res 2009;11(2):111-21. doi: 10.1093/ntr/ntp010

9. Reyes-Guzman CM, Pfeiffer RM, Lubin J, et al. Determinants of Light and Intermittent Smoking in the United States: Results from Three Pooled National Health Surveys. Cancer Epidemiol Biomarkers Prev 2017;26(2):228-39. doi: 10.1158/1055-9965.EPI-16-0028

10. Thrul J, Buhler A, Ferguson SG. Situational and mood factors associated with smoking in young adult light and heavy smokers. Drug Alcohol Rev 2014;33(4):420-7. doi: 10.1111/dar.12164

11. Wetter DW, Kenford SL, Welsch SK, et al. Prevalence and predictors of transitions in smoking behavior among college students. Health Psychol 2004;23(2):168-77. doi: 10.1037/0278-6133.23.2.168

12. Hoeppner BB, Bidwell LC, Colby SM, et al. Smoking patterns and their relationship to drinking among first-year college students. Nicotine Tob Res 2014;16(6):743-52. doi: 10.1093/ntr/ntt205

13. Hukkinen M, Kaprio J, Broms U, et al. Characteristics and consistency of light smoking: long-term follow-up among Finnish adults. Nicotine Tob Res 2009;11(7):797-805. doi: 10.1093/ntr/ntp065

14. Levy DE, Biener L, Rigotti NA. The natural history of light smokers: a population-based cohort study. Nicotine Tob Res 2009;11(2):156-63. doi: 10.1093/ntr/ntp011

15. White HR, Bray BC, Fleming CB, et al. Transitions into and out of light and intermittent smoking during emerging adulthood. Nicotine Tob Res 2009;11(2):211-9. doi: 10.1093/ntr/ntn017

16. Duncan DT, Kawachi I. Neighborhoods and Health: A Progress Report. In: Duncan DT, Kawachi I, eds. Neighborhoods and Health. 2nd ed. New York, NY: Oxford University Press 2018.

17. McDaniel PA, Smith EA, Malone RE. The tobacco endgame: a qualitative review and synthesis. Tob Control 2016;25(5):594-604. doi: 10.1136/tobaccocontrol-2015-052356

18. Moon G, Barnett R, Pearce J, et al. The tobacco endgame: The neglected role of place and environment. Health Place 2018;53:271-78. doi: 10.1016/j.healthplace.2018.06.012

19. Algren MH, Bak CK, Berg-Beckhoff G, et al. Health-Risk Behaviour in Deprived Neighbourhoods Compared with Non-Deprived Neighbourhoods: A Systematic Literature Review of Quantitative Observational Studies. PLoS One 2015;10(10):e0139297. doi: 10.1371/journal.pone.0139297

20. McCarthy WJ, Mistry R, Lu Y, et al. Density of tobacco retailers near schools: effects on tobacco use among students. Am J Public Health 2009;99(11):2006-13. doi: 10.2105/AJPH.2008.145128

21. Pokorny SB, Jason LA, Schoeny ME. The relation of retail tobacco availability to initiation and continued smoking. J Clin Child Adolesc Psychol 2003;32(2):193-204. doi: 10.1207/S15374424JCCP3202_4

22. Pearce J, Barnett R, Moon G. Sociospatial inequalities in health-related behaviours: Pathways linking place and smoking. Progress in Human Geography 2012;36(1):3-24.

23. Schneider JE, Reid RJ, Peterson NA, et al. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. Prev Sci 2005;6(4):319-25. doi: 10.1007/s11121-005-0016-z

24. Chaiton MO, Mecredy G, Cohen J. Tobacco retail availability and risk of relapse among smokers who make a quit attempt: a population based cohort study. Tob Control 2017(0):1-7. doi: 10.1136/tobaccocontrol-2016-053490

25. Robertson L, McGee R, Marsh L, et al. A systematic review on the impact of point-of-sale tobacco promotion on smoking. Nicotine Tob Res 2015;17(1):2-17. doi: 10.1093/ntr/ntu168

26. Kirchner TR, Cantrell J, Anesetti-Rothermel A, et al. Geospatial exposure to point-of-sale tobacco: real-time craving and smoking-cessation outcomes. Am J Prev Med 2013;45(4):379-85. doi: 10.1016/j.amepre.2013.05.016

27. Watkins KL, Regan SD, Nguyen N, et al. Advancing cessation research by integrating EMA and geospatial methodologies: associations between tobacco retail outlets and real-time smoking urges during a quit attempt. Nicotine Tob Res 2014;16 Suppl 2:S93-101. doi: 10.1093/ntr/ntt135

28. Chaiton M, Diemert L, Zhang B, et al. Exposure to smoking on patios and quitting: a population representative longitudinal cohort study. Tob Control 2016;25(1):83-8. doi: 10.1136/tobaccocontrol-2014-051761

29. Ghenadenik AE, Frohlich KL, Gauvin L. Beyond Smoking Prevalence: Exploring the Variability of Associations between Neighborhood Exposures across Two Nested Spatial Units and Two-Year Smoking Trajectory among Young Adults. Int J Environ Res Public Health 2016;13(1) doi: 10.3390/ijerph13010106

30. Frohlich KL, Shareck M, Vallee J, et al. Cohort Profile: The Interdisciplinary Study of Inequalities in Smoking (ISIS). Int J Epidemiol 2015 doi: 10.1093/ije/dyv036

31. DMTI Spatial Inc. Enhanced Points of Interest v.3. Markham, Canada, 2011.

32. Clary C, Kestens Y. Field validation of secondary data sources: A novel measure of representativity applied to a Canadian food outlet database. Int J Behav Nutr Phys Act 2013;10:1-9.

33. Statistics Canada. Census Dictionary: Dissemination Area (DA) 2016 [Available from: http://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo021-eng.cfm accessed February 7, 2019.

34. Shareck M, Dassa C, Frohlich KL. Improving the measurement of neighbourhood characteristics through systematic observation: inequalities in smoking as a case study. Health Place 2012;18(3):671-82. doi: 10.1016/j.healthplace.2011.11.008

35. Dierker L, He J, Kalaydjian A, et al. The importance of timing of transitions for risk of regular smoking and nicotine dependence. Ann Behav Med 2008;36(1):87-92. doi: 10.1007/s12160-008-9051-x

36. Statistics Canada. Canadian Community Health Survey - Annual Component (CCHS) 2017 [Available from: http://www23.statcan.gc.ca/imdb/p3Instr.pl?Function=getInstrumentList&Item_Id=507367&UL=1V accessed February 7, 2019.

37. Gagné T, Ghenadenik AE, Shareck M, et al. Expected or completed? Comparing two measures of education and their relationship with social inequalities in health among young adults. Social Indicators Research 2018;135(2):549-62.

38. Pampalon R, Hamel D, Gamache P, et al. An Area-based Material and Social Deprivation Index for Public Health in Québec and Canada. Can J Public Health 2012;103(S2):S17-S22.

39. Tabachnick BG, Fidell LS. Using Multivariate Statistics. 6th ed. Boston, MA: Pearson Education 2013:786-861.

40. Barnett R, Moon G, Pearce J, et al. Smoking Geographies: Space, Place and Tobacco. West Sussex, UK: Wiley Blackwell 2017.

41. Rice N, Godfrey C, Slack R, et al. A systematic review of the effects of price on the smoking behaviour of young people. York, UK: Public Health Research Consortium, 2010.

42. Shadel WG, Martino SC, Setodji C, et al. Momentary effects of exposure to prosmoking media on college students' future smoking risk. Health Psychology 2012;31(4):460-66. doi: 10.1037/a0027291

43. Canadian Cancer Society. Overview Summary of Federal/Provincial/Territorial Tobacco Control Legislation in Canada, 2017:123.

44. Paul CL, Mee KJ, Judd TM, et al. Anywhere, anytime: retail access to tobacco in New South Wales and its potential impact on consumption and quitting. Soc Sci Med 2010;71(4):799-806. doi: 10.1016/j.socscimed.2010.05.011

45. Pearce J, Rind E, Shortt N, et al. Tobacco Retail Environments and Social Inequalities in Individual-Level Smoking and Cessation Among Scottish Adults. Nicotine Tob Res 2016;18(2):138-46. doi: 10.1093/ntr/ntv089

46. Rooke C, Amos A, Highet G, et al. Smoking spaces and practices in pubs, bars and clubs: young adults and the English smokefree legislation. Health Place 2013;19:108-15. doi: 10.1016/j.healthplace.2012.10.009

CHAPTER 5: DISCUSSION

5.1 A brief recapitulation of the context and objectives of this dissertation

The dramatic reduction in smoking prevalence that took place since the 1950s across different countries including Canada (230) has been hailed as one of public health's greatest successes. Nonetheless, reduction rates have not been consistent across populations (230). This is the case of young adults, who as discussed previously represent the group with the highest prevalence of smoking in Canada (43) and whose smoking rates have remained virtually unchanged in recent years (44).

The health and place literature has highlighted the importance of residential environments in shaping smoking outcomes (112). However, since this body of research tends to be focused on point-specific measures of smoking initiation, prevalence, quit attempts and cessation rates, it is unable to examine the potential influence of residential features on smoking behaviour patterns. This is particularly problematic among young adults, given their variable smoking behaviour (30-32). Moreover, as highlighted by Duncan and Kawachi (2018) a number of challenges limit our ability to identify potential determinants of health behaviour, including the need for increased specificity regarding both contextual features and health outcomes, and the need to use designs that acknowledge multiple spatial scales (12).

In light of these issues, the main objective of this dissertation was to advance knowledge regarding smoking behaviour patterns among young adults and their associations with residential environment features. Overall, findings from this thesis provide insights into the complex nature of smoking behaviour in this age group, the potential for residential environment features to influence distinct smoking behaviour patterns and the scales at which associations between features and patterns may be best observed. Beyond their relevance to tobacco use in young adults, these results underscore the need to pay attention to the different health behaviour patterns displayed by this population that may arise as a result of significant changes in life circumstances taking place during this period (231). These findings in turn provide support for a more nuanced examination of the potential of distinct features on specific health behaviour patterns towards more effective public health policy and intervention (12).

The remainder of this chapter will discuss the main findings of this dissertation, to then go on to present overall strengths and limitations, and finally propose potential implications for public health research and intervention.

5.2 Summary of main findings

This dissertation sought to answer three specific questions: 1) can smoking behaviour in young adults be better described and conceptualized by examining smoking behaviour patterns over time, beyond point-specific smoking outcomes? 2) are specific features of residential environments associated with distinct smoking behaviour patterns? and 3) does the presence and strength of these associations vary at different spatial scales?

This thesis uncovered significant associations between residential environment features and distinct smoking behaviour patterns. This results suggest that a different picture may emerge once smoking is studied not only in terms of static outcomes, but also taking into consideration the different behavioural patterns that may take place over time. Furthermore, the presence of variable smoking patterns and their association with specific environmental features underscore the need to examine them in detail, especially in light of the inherently variable nature of smoking behaviour among young adults (30-32). Also, the presence of associations between specific features of residential environments and different types of behavioural patterns (e.g.: presence of smoker accommodation facilities associated with persistent smoking, presence and density of tobacco retail also associated with variable smoking behaviour patterns) highlight the need to examine the potential for these factors to exert different levels of influence on specific patterns. Finally, the presence of scale-specific associations between residential environment features and smoking behaviour patterns provides support to theoretical propositions positing that processes underlying associations between environmental features and health outcomes may take place at different scales depending on the specific exposure-outcome pair under analysis (11), and reinforce the need to acknowledge and examine scale-related issues in health and place research (6, 67, 68, 174). These three themes will be discussed in further detail in the following sections, both in light of the health and place literature and the results from this dissertation.

5.3 Can smoking behaviour in young adults be better described and conceptualized by examining smoking behaviour patterns over time, beyond point-specific smoking outcomes?

In response to the first objective of this thesis, findings from the three articles highlight the need to acknowledge the existence of distinct smoking behaviour patterns that may be experienced by young adults and provide relevant insights concerning their description and conceptualization. Moreover, they highlight the importance of going beyond point-specific measures of smoking initiation, prevalence, and cessation, to also capture variable patterns composed of different changes in smoking status over time.

In the case of the ISIS cohort, whereas many participants reported either a smoker or a non-smoker status at every time of measure, it is interesting to note that a significant proportion of young adults in this sample displayed more variable smoking patterns. Specifically, at baseline almost 44% of ever-smoking young adults were either smokers for fewer than 2 years or non-smokers for fewer than 2 years. Similar proportions were found at follow-up, nonetheless with a larger proportion of newer smokers. This variability becomes even more evident when looking at 4-year smoking trajectories and speaks to the importance of examining specific patterns in detail: among ever-smokers only 37% were persistent smokers whereas the remaining 63% exhibited more variable smoking behaviour patterns (see Table 5.1 below for details).

Table 5.1 Smoking behaviour patterns among ever-smoker young adults in the ISIS cohort

	T0-T1 Smoking Pattern (n=729)	**T1-T2 Smoking Pattern (n=375)**	**4-Year Smoking Pattern (n=474)**
Smoker ≥ 2 years or Persistent Smoker, n (%)	409 (56.1%)	213 (56.8%)	176 (37.1%)
Smoker < 2 years or New Smoker, n (%)	68 (9.3%)	85 (22.7%)	53 (11.2%)
Non-Smoker < 2 years or Ex-Smoker, n (%)	252 (34.6%)	77 (20.5%)	181 (38.2%)
Switcher*, n (%)	n/a	n/a	64 (13.5%)
Ever-Smokers, n (%)	729	375	474

* For the purposes of this dissertation, participants who had reported a different smoking status at each survey point (e.g.: smoker 2 years prior to baseline, non-smoker at baseline, smoker 2 years after baseline) were categorized as switchers

This variability is not exclusive of smoking behaviour: young adults experience significant changes in other health behaviours during this life stage, including physical activity, alcohol use, dietary patterns, and sexual behaviour (33, 40, 232-234). For example, the results from a study of an intervention targeting heavy-drinking college students showed that in the control group the frequency of risky alcohol consumption over a 4-year period, although essentially unchanged in the longer term, displayed a visible variability at each yearly point of measure (29). Beyond changes in substance use, young adulthood also tends to be a period marked by decreasing levels of physical activity (33, 34, 234), a progressive adoption of unhealthy diets (35, 234), and an increase in sedentary behaviour (34). These changes are hardly surprising given the pivotal transitions in life circumstances that young adults typically go through (231), which in turn have the potential to alter health behaviours established earlier in life (54).

From a life-course perspective (235) young adulthood represents a unique stage within which individuals are more sensitive to environmental inputs that may contribute to shape health behaviour patterns (40). The importance of young adulthood as a period relevant to the adoption and consolidation of health behaviours is being increasingly highlighted, as well as recognized as a crucial time for intervention on long-term health behaviour patterns (233). Given this, calls have been made to undertake research, policy and surveillance efforts with an exclusive focus on young adulthood instead of conceptualizing this period as either an extension of adolescence or as part of adulthood (231). Recent years have seen an increase in the production of work seeking to address knowledge gaps concerning young adults' health and well-being (an example is the 2015 Institute of Medicine's *Investing in the Health and Well-Being of Young Adults* report (231)). Nonetheless, as it pertains to tobacco use, despite a growing number of studies on smoking specific to this age group, relatively few have devoted their attention to measures of smoking behaviour over time, and to the best of my knowledge, none have examined variable smoking patterns and their potential determinants. Findings from this dissertation contribute to advancing knowledge concerning smoking in young adults by suggesting that even in the face of stable smoking rates there is a need to devote attention to distinct smoking patterns (e.g.: persistent smokers, switchers, new smokers, new non-smokers and never smokers) that can account for the evolution of smoking behaviour over time. Moreover, since changes in other health behaviours are likely to take place during this life period, a similar research approach that includes the identification of distinct patterns and

factors that may influence them may be a fruitful avenue to contribute to improving health outcomes in this population.

Results from this thesis show some differences in smoking behaviour patterns related to individual-level characteristics. As expected, older young adults tended to have higher odds of being persistent smokers, and lower odds of being new smokers. Sex-related differences in smoking behaviour patterns were detected in Article 1: female participants were less likely to be smokers for 2 years or longer than their male counterparts. However, no associations between sex and smoking behaviour patterns were detected in Articles 2 and 3. In line with findings from Article 1, some studies have reported sex-related differences in smoking behaviour, suggesting a lower likelihood of progression to heavier and/or daily smoking among women (31, 32, 85). Therefore, further studies seeking to examine sex-related differences in smoking behaviour are warranted. Finally, although socioeconomic position (SEP) is a well-know correlate of smoking prevalence, initiation, and cessation (236, 237), no associations between SEP and smoking behaviour patterns were detected in this thesis. These results may suggest that the role of SEP in shaping smoking behaviour patterns may be different to that related to point-specific outcomes. Similar to potential sex-related pattern differences, SEP-related differences in smoking behaviour patterns should be examined in future research.

Finally. as highlighted previously, residential environment features are thought to play an important role in shaping young adult smoking behaviour. The next section will discuss the potential influence of these features on this population's smoking behaviour patterns in light of the findings from this thesis.

5.4 Are specific residential environment factors associated with different smoking behaviour patterns? Does the presence and strength of these associations vary at different spatial scales?

A common theme across articles was the presence of significant scale-specific associations between residential environment features and smoking behaviour patterns. These associations, in line with a host of studies of places and smoking, underscore the importance of residential environments in terms of their potential to influence smoking behaviour. Furthermore, findings from this dissertation underscore several important points. First, as suggested in a few tobacco use

studies (62, 63) and in line with findings from research on other health behaviours such as diet and physical activity (59-61), they provide evidence of the potential role played by specific features in shaping *smoking behaviour patterns* in young adults. Furthermore, associations between specific residential environment features and discrete smoking patterns suggest that distinct mechanisms underlying these associations may be at play. Finally, findings revealing scale-specific associations suggest that specific processes linking residential environment features and smoking behaviour patterns may operate at different spatial scales. The specificity of associations between distinct smoking behaviour patterns and specific residential environment features, as well as the presence of scale-related differences in presence and strength of associations, underscores the need for a more nuanced approach capable of capturing different behavioural patterns and their associations with environmental features at different scales, not only pertaining to smoking among young adults, but also to other health behaviours.

Since its "renaissance" a few decades ago, the health and place literature has made significant contributions to advancing knowledge regarding the potential influence of neighbourhood features on health behaviours and outcomes. This research, initially focused on the potential influence of the general characteristics of local areas (e.g.: neighbourhood deprivation) on health outcomes, allowed for the identification and quantification of area-based disparities. Whereas these studies have made significant contributions to this field, an important shortcoming of this more global approach is its relatively limited ability to provide information concerning the potential influence of specific environmental features on health outcomes, which in turn poses hurdles to effective public health policy and intervention. Seeking to address this knowledge gap, more recently studies have increased their specificity in the examination of places and health, both in terms of contextual features and health outcomes (12). The second objective of this dissertation aimed to acknowledge this need by examining how specific smoking behaviour patterns may be influenced by different environmental features. The results from these analyses will be discussed below.

5.4.1 Variable and persistent smoking behaviour: the role of local and proximal-level presence and density of tobacco retail

Findings from this thesis uncovered significant associations between presence and density of tobacco retail stores in relative proximity to residential addresses and smoking behaviour patterns

in young adults. Specifically, Article 2 showed that individuals residing in local-level areas (sociological neighbourhoods) with a greater presence of tobacco retail stores were less likely to be new non-smokers (see Figure 5.1 below), whereas results from Article 3 showed that young adults residing in proximal-level areas (dissemination areas) with a higher density of tobacco retail were more likely to have repeatedly changed their smoking status over the course of 4 years, to be persistent smokers, and to be ex-smokers (see Figure 5.2 below).

Figure 5.1 Two-year likelihood of being a non-smoker for fewer than 2 years by SN-level exposure to residential environment features

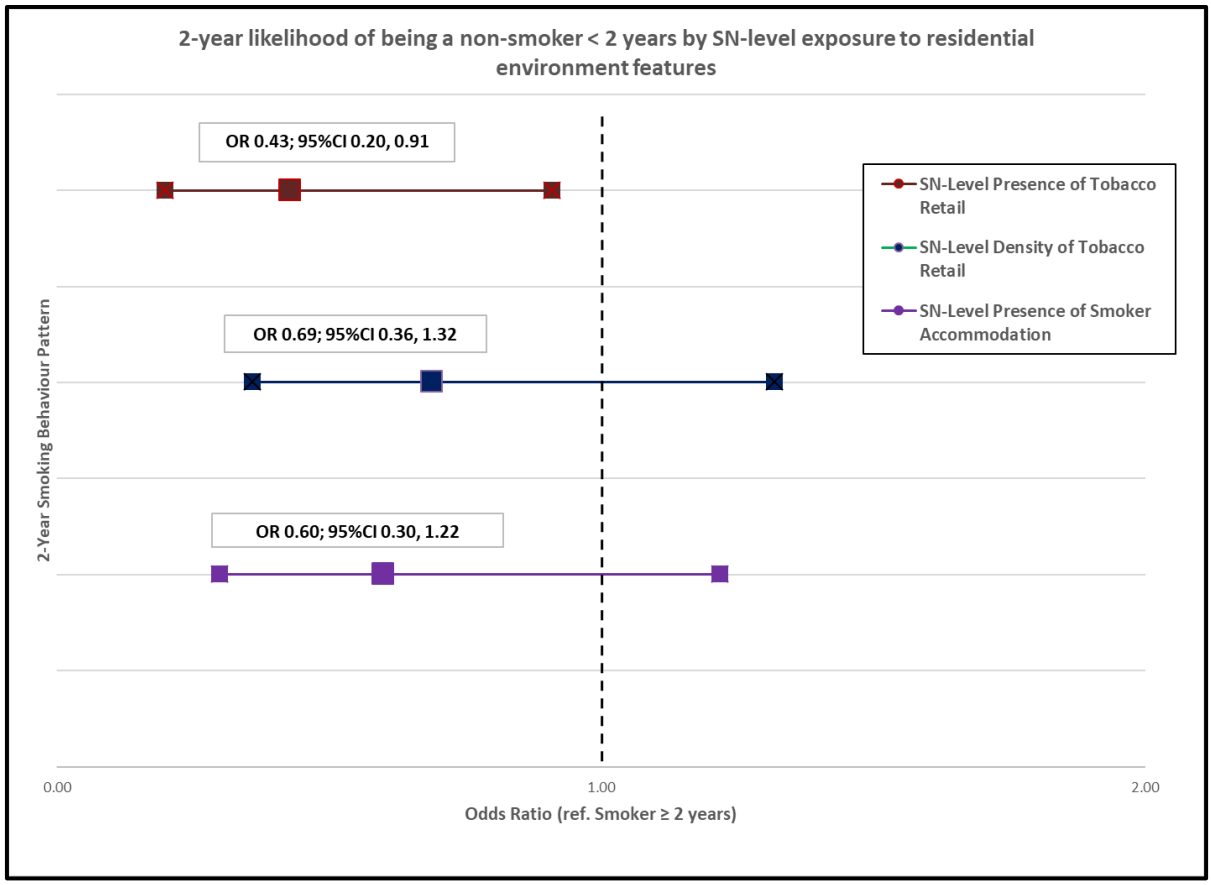
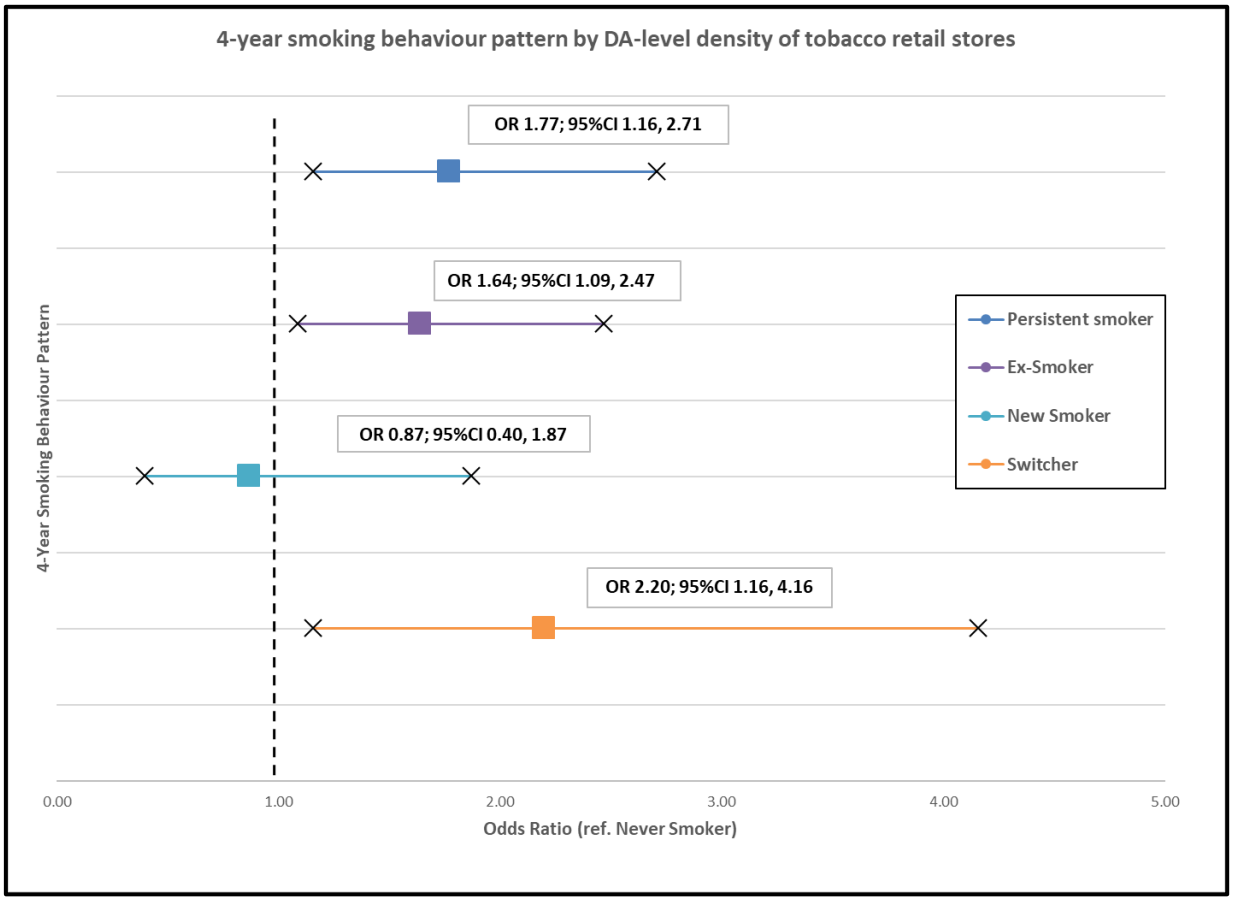


Figure 5.2 Four-year smoking behaviour pattern by DA-level density of tobacco retail



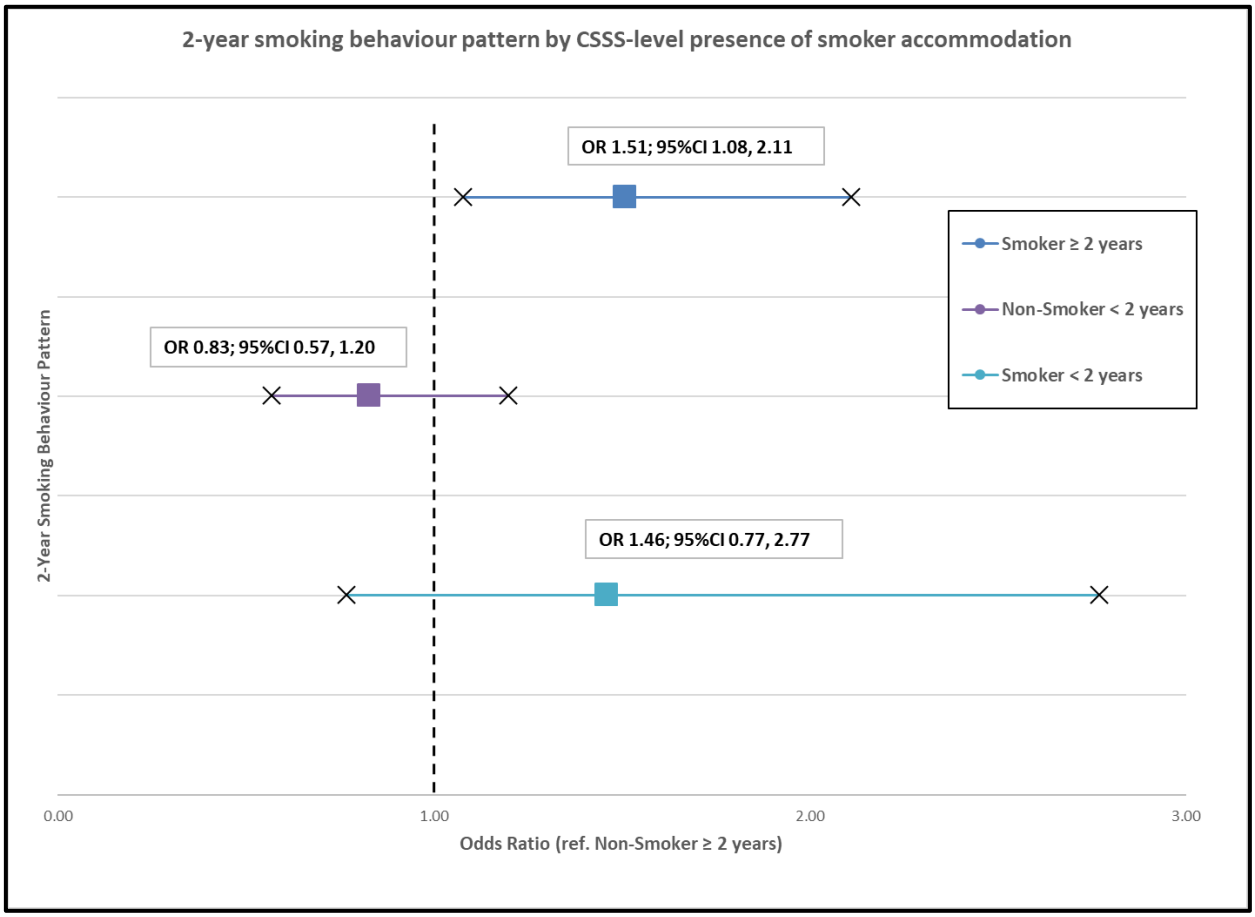
These results suggest that this feature may influence certain smoking behaviour patterns at more proximal scales. Associations between variable patterns and a higher density of tobacco retail stores in close proximity to where young adults reside highlight the potential for this feature to foster smoking through reduced search costs, lower prices and a higher exposure to environmental cues that may trigger cravings and impulse purchases (150, 238, 239). A greater neighbourhood-level presence of tobacco stores may on the other hand play a role in sustaining smoking among those with a more established pattern via increased accessibility and availability of tobacco products. From an etiological perspective, these results suggest that this feature may have a scale-specific influence on different types of smoking behaviour patterns. Therefore, scale-related differences in associations between distinct patterns and this exposure should be further examined, as this information may prove useful to orient public health interventions aiming to reduce smoking prevalence in young adults (e.g.: by identifying smoking behaviour patterns most prevalent at a given geographic scale and targeting the environmental features that are most likely

to influence them). Moreover, in light of the literature regarding the role and proposed mechanisms linking the presence and density of tobacco retail to smoking behaviour, findings from this dissertation pointing to the potential influence of this feature on variable and persistent smoking patterns support further investigation concerning approaches seeking to restrict local-level distribution of tobacco products as a means to curb smoking in young adults. Potential strategies related to limiting local distribution will be discussed in the last section of this chapter.

5.4.2 Presence of smoker accommodation facilities and smoking maintenance in young adults

Results from Article 1 uncovered significant associations between the presence of smoker accommodation facilities and a persistent smoker pattern. Specifically, analyses from this paper detected an association between a greater regional-level presence of this feature and a higher likelihood of being a smoker for 2 years or longer (see Figure 5.3 below). These results suggest that smoker accommodation facilities may contribute to sustaining smoking in young adults at a more regional level. This may be reflective of larger areas centered around residential addresses within which young adults are exposed to this feature (e.g.: higher concentrations of bars and restaurants in more dense urban areas, which in turn may result in higher concentrations of smoker accommodation facilities, as is the case of the Island of Montreal (see Appendix VIII for a Getis-Ord GI* hotspot analysis showing higher concentrations of this feature within the central urban core)

Figure 5.3 Two-year smoking behaviour pattern by CSSS-level of smoker accommodation



Aside from mechanisms discussed in previous chapters, smoker accommodation facilities may help sustain smoking through an increased exposure to social cues and by allowing individuals to smoke in normalized settings without fear of stigmatization and negative perceptions of their habit. For example, a 2002 paper seeking to gauge smokers' perceptions regarding a smoking ban in bars, nightclubs and gaming venues in Australia reported that the majority of smokers attending these places smoked more as a result of increased social cues, whereas some indicated that they may quit if smoking were to be banned in these places (240). Of note, in this study participants under the age of 30 years were more likely to be socially-cued smokers compared to their older counterparts.

The potential enabling role of smoker accommodation facilities has been reported in a few qualitative studies of outdoor smoking behaviour following indoor smoking bans. Paradoxically,

although the enactment of smoke-free legislation typically contributes to further denormalize (and stigmatize) this behaviour, two studies of smoking practices in pubs, bars and clubs following indoor smoking bans in England (241) and Scotland (156) showed how these venues had been reshaped to accommodate smokers in outdoor areas, in several cases providing contexts where not only smoking is permitted, but can also be seen as a positive, sociable and pleasant activity for individuals of different age groups including young adults (241). Participant verbatims from these papers help illustrate this point:

> *"[…] my local must have spent a fortune. They've built this smoking beergarden […] there's never been anything outside before. So they've put this beautiful big garden out the back […]"* (241)

> *"[…] they've got the furniture outside and everything, and it's pretty enclosed, there's a gate, so you're not really going out on the street and there's not drunk people outside or anything, so it's pretty OK, and the security guard's there, so you're safe. That's where I go, 'cause I like the whole idea, it feels like you're in a garden or something […]"* (241)

> *"[…] the pub that I drink in has been fantastic with the smoking ban, they've put out a big gas heater sponsored by Foster's. And it's got a canopy; he has got a gazebo over it. And a couple of folding chairs and what have you, it's actually quite nice […]"* (156)

These examples suggest that partial, indoors-only smoking bans in hospitality venues are unlikely to be effective as tobacco control initiatives. Recent years have witnessed an extension of smoking bans to also include outdoor smoker accommodation facilities in hospitality venues in several jurisdictions (242) including municipalities, counties and/or states/provinces in Australia, New Zealand, the United States, and Canada (57, 157, 243). In contrast with indoors-only bans, these efforts seem to have a significant impact on smoking behaviour. Evidence of these effects has been provided in Nagelhout et al.'s (2012) study comparing quit attempts and smoking cessation rates between two countries with comprehensive bans (legislation prohibiting smoking

in all bars/restaurants' areas, enacted in Ireland and England) and the Netherlands, which at the time did not restrict smoking in outdoor patios and terraces (244). Results from this paper show that whereas quit attempts and cessation rates increased after the enactment of comprehensive bans in England and Ireland, rates remained essentially unchanged in the Netherlands.

Findings from this dissertation provide additional evidence of the suboptimal impact of indoor smoking bans and point to the need to pursue comprehensive legislation that includes outdoor areas. Legislation prohibiting smoking in outdoor patios and terraces has been enacted in the province of Quebec in 2016 (58), two years after follow-up of the analytical sample used in this dissertation. Research examining the overall impact of these regulations would be important to improve our understanding of the influence of smoker accommodation features on smoking behaviour.

5.5 Strengths and limitations

5.5.1 Strengths

This dissertation has several important strengths. First, the examination of different smoking behaviour patterns in young adults sheds light on dynamics that underlie smoking outcomes at discrete time points (i.e.: smoking prevalence, quit attempts, initiation rates). As suggested all along in this dissertation, this knowledge is vital to better understand smoking behaviour in this age group, given that this population is likely to experience repeated changes in smoking behaviour during this life period. The relevance of examining smoking behaviour patterns is highlighted by results showing associations between specific patterns and residential environment features. Second, the longitudinal measure of smoking behaviour patterns used in Articles 2 and 3 provides a stronger basis for causal inference. This strength is worth highlighting in the context of a large number of studies of places and smoking using cross-sectional designs.

A third strength of this dissertation is the ackowledgment of spatial scale issues and consequent examination of associations using different types of spatial units. As discussed previously, results from this thesis provide evidence of scale-specific associations between residential environment features and smoking behaviour patterns. In spite of potential limitations related to the choice of spatial units used in this dissertation, the examination of associations at different spatial scales can

contribute to reducing measurement error and may help orient knowledge regarding the scales at which processes underlying these associations operate. These results could be used to guide future studies interested in the examination of scale-related differences in associations between residential environment features and smoking behaviour. Finally, a key strength of this dissertation is its reliance on data from the ISIS cohort. Although progressively acknowledged as an important area of focus for public health, research specific to young adults is still scarce. In this regard the ISIS study, by virtue of its large sample of young adults and extensive data collected both at the individual and contextual level has allowed me to dig deeper into the different smoking patterns that may take place during this period, and to better understand contextual factors that may influence these behaviours.

5.5.2 Limitations

Some of the limitations of this dissertation were discussed in each of the three articles detailed in the Results chapter. Additional limitations will be discussed in this section.

Data-related limitations

Certain limitations concerning the variables used to operationalize residential environment features and smoking behaviour patterns may have introduced some bias. First, although presence and density of tobacco retail were measured using a fairly contemporaneous validated data source (the 2011 version of DMTI's Enhanced Points of Interest© database), changes related to the retail environment may have still occurred between the time of data capture and when individuals responded to the baseline questionnaire (November 2011 to September 2012). Moreover, although this source had acceptable sensitivity and positive predictive values, some level of exposure misclassification cannot be ruled out, hence potentially impacting estimates of association.

Second, the presence of smoker accommodation facilities was measured by direct observation of the dissemination areas (DA) of residence of respondents. Since other DAs on the Island of Montreal were not observed, this feature may have been understated due to unmeasured DAs nested within the two larger spatial units (SNs and CSSSs). In the same vein, other elements of smoker accommodation beyond the four items included in the measure used in this thesis (e.g.: outdoor spaces in places other than hospitality venues) would not have been captured in analyses,

therefore potentially understating exposure to this feature and its potential impact on smoking behaviour patterns.

Finally, given that these features were measured only once, at baseline, any changes that may have occurred between baseline and follow-up would not have been captured in analyses. Future research examining associations between changes in exposure to residential environment characteristics and smoking behaviour patterns will be necessary to further advance knowledge in this area and to delve deeper into potential causal links. Also, although Articles 2 and 3 included supplementary analyses using alternative operationalizations of tobacco retail density (i.e.: using a variety of quantiles including median split, top tertile, top quartile and top quintile) to test the robustness of results, it would have been interesting to examine the presence of a gradient related to different levels of exposure to residential environment features. This is a potential area of inquiry for future studies in this area.

Also, and in more general terms, whereas the objective of this thesis was to examine the potential role of residential environment features on smoking behaviour patterns among young adults, it is clear that a vast array of determinants can influence smoking (245). These range from individual characteristics including age, gender, educational attainment, ethnicity and genetic factors, to contextual elements such as physical, socioeconomic and political environments. Whereas some of these factors were included in models as covariates, many others could have had an impact on model results (e.g.: local-level norms around smoking, which are likely to be correlated with tobacco availability and smoking accommodation),

Limitations concerning smoking outcome variables should also be acknowledged. First, measures of smoking behaviour were self-reported, therefore potentially differing from those based on biochemical markers. Having said that, self-reported smoking behaviour has been shown to be an accurate predictor of objective measures of tobacco use (246), therefore deemded appropriate and being widely used in most countries including Canada (247). Second, some categories of the variables examined in this dissertation had a relatively low number of participants. Although associations were detected for some of them, in certain cases this ability may have been limited. Also, since smoking outcomes were measured at two-year intervals, any

short-term changes in smoking behaviour would not have been captured by analyses. Nonetheless, this is of relatively lesser concern, given that my interest was to examine longer-term smoking patterns, especially in light of the variability in smoking behaviour among young adults.

A limitation concerning the covariates used in fully-adjusted models is the use of educational attainment as a proxy for socioeconomic position (SEP). Although this is generally thought to be one of the most appropriate indicators of SEP among young adults, at least in developed countries (223-225), several other mechanisms linking SEP and smoking behaviour may be at play (53, 248), and therefore not adequately captured by measures of educational attainment. Studies using other SEP indicators may be of interest, as they may modify associations between residential environment features and smoking behaviour patterns among young adults.

Also, it would have been interesting to examine changes in smoking intensity as a covariate, and also as a component of the smoking behaviour pattern measure. This approach has been explored in preliminary models, however the low number of participants for which complete, reliable data was available was too small to detect any potential effects. The incorporation of this element to smoking behaviour pattern measures is likely to be a promising avenue for future research. Similarly, other behavioural dimensions, notably quit intentions and quit attempts should be incorporated in future studies, as they would provide additional insights into different patterns of smoking behaviour.

Finally, limitations regarding the spatial scales used in the analyses should be noted. As discussed in the literature review chapter, different approaches may be taken to operationalize spatial units, including egocentric areas or as is the case in this dissertation, territorial-based units. The objective of this thesis was to capture the residential environments to which young adults may be exposed to in relationship to their smoking behaviour. To this end, the two smaller spatial unit types, sociological neighbourhoods (SNs) and dissemination areas (DAs), were used as proxies for local areas (SNs) and areas in close proximity to residences (DAs) respectively. A third unit type, health and social services centres (CSSSs) was used to also include larger areas centered around residential addresses. Although similar-sized units have been extensively used in the literature, the three definitions used in this dissertation were driven by data availability. Therefore, as is the case

with all research examining spatial-based phenomena, the potential for the modifiable areal unit problem (MAUP) cannot be ruled out. As a reminder to the reader, MAUP may be at the base of differences in associations between environmental features and health outcomes depending on the scale at which data are aggregated and how boundaries are established to define areas (25). The use of the above-mentioned unit types not only served to examine associations at different scales, but were also used to mitigate potential MAUP-related differences in results. Nonetheless, whereas these definitions allowed me to detect significant associations between smoking behaviour patterns and residential environment features, these scales may differ from the "true" scales at which underlying processes operate. Future epidemiological studies in this area should keep abreast of the latest developments in health geography regarding this issue, given that this discipline has typically produced most of the groundbreaking research in this area. Also, whereas this thesis was focused on residential environments, it is well understood that although a very important setting of daily living, there are other areas to which individuals are exposed, including academic, occupational and leisure spaces (249-251). Therefore, while this dissertation provides important information concerning the potential role of residental environmental features on smoking behaviour patterns, this area of inquiry should be extended to other activity spaces that take into account daily mobility.

5.6 Implications for public health and health promotion

5.6.1 Extending research and surveillance beyond measures of smoking status

A salient theme across findings from this thesis is the need to identify and understand different smoking behaviour patterns among young adults, especially in light of their variability. This is particularly important within a context of stagnating smoking prevalence rates in this age group (43), which poses additional hurdles to the achievement of the aggressive smoking prevalence reduction goals proposed by a number of countries, provinces and other jurisdictions (252). Therefore, I argue that research and surveillance efforts should also capture and examine smoking behaviour patterns (and other health behaviour patterns as well).

Nonetheless, most national and subnational health surveillance systems are based on cross-sectional data (e.g.: the Behavioral Risk Factors Surveillance System (BRFSS) (253) and the National Health and Nutrition Examination Survey (NHANES) (254) in the United States or the

Canadian Chronic Disease Surveillance System (CCDSS) (255), to mention a few), and therefore are not capable of monitoring health behaviour patterns. Hence, as highlighted by the Institute of Medicine's *A Nationwide Framework for Surveillance of Cardiovascular and Chronic Lung Diseases* (256), population-representative cohort studies may help overcome these limitations. Examples of cohort studies that are or may be used in chronic disease and health behaviour surveillance include the Coronary Artery Risk Development in Young Adults Study (CARDIA) in the United States (257), and the Millennium Cohort Study (MCS) in the United Kingdom (258). Data collected in these studies typically cover a variety of outcomes and health behaviours that can be used to monitor health behaviour patterns. For example, in the case of MCS, information on physical activity, dietary habits, alcohol consumption and smoking is periodically obtained for a cohort of 19,000 individuals born between 2000 and 2001.

As it pertains to surveillance, aside from potentially implementing similar efforts at different levels/jurisdictions, public health organizations can resort to data from existing cohort studies as a means to monitor health behaviour patterns over time. In the case of Canada, these initiatives could incorporated to Health Canada's purview, as well as to provincial and other subnational organizations' responsible for population health. Also, since data from these studies tends to be freely available to bona fide researchers, this information could be used in future research in this area.

From a conceptual standpoint, results from this thesis support the need to challenge theoretical models of health behaviour that assume stable progression patterns, and call for consideration of approaches that conceptualize these behaviours in terms of patterns that may be subject to variation over time. Indeed, these findings can be used to guide studies seeking to examine the natural history of smoking behaviour patterns among young adults, which in turn, as suggested in Rothman et al.'s theoretical framework of long-term behaviour change (28) can be use to uncover details concerning behaviour maintenance processes. Furthermore, these results may be used to inform theories of smoking behaviour that acknowledge the existence of emergent, variable and consolidated behavioural patterns among young adults, and should therefore be continued to be explored in future research.

5.6.2 Restricting distribution of tobacco products

Findings from this dissertation suggest that the presence and density of tobacco retail play an important role in shaping smoking behaviour patterns among young adults both by exacerbating switches in smoking status and by sustaining smoking over time. An important mechanism by which this feature is thought to influence smoking behaviour is through an increased exposure to advertising and promotion at the point of sale (POS). Consequently, most forms of POS marketing tactics such as tobacco product displays including "power walls" (which display packs in prominent store positions) and in-store promotional paraphernalia have been progressively banned in several countries, mostly during the last decade (as of 2016 product display bans have been enacted in all Canadian jurisdictions, Australia, Belarus, British Virgin Islands, Chile, Croatia, Finland, Hungary, Iceland, Ireland, Kenya, Morocco, New Zealand, Norway, Russia, Thailand, the United Kingdom, Ukraine, Uruguay and Uzbekistan) (259).

Nonetheless, since the presence/concentration of retail stores itself can significantly influence smoking behaviour, public health action towards restricting distribution has been highlighted by some authors as the "next frontier" in tobacco control (260, 261). Several strategies have been proposed in the literature as potential approaches to reduce the number and density of tobacco retailers. These include: 1) banning sales of tobacco products at certain types of retailers (e.g.: pharmacies), 2) prohibiting store locations within a certain distance of establishments serving youth, 3) regulations requiring a minimum distance between retailers, 4) implementing caps on store counts by geographic area, 5) limiting the number of tobacco retailers in proportion to population size, and 6) restricting sales to tobacco-only stores (262).

The potential efficacy of these strategies has been discussed in the literature, and is supported by findings from this dissertation. In the case of sales bans in specific venues, aside from limiting accessibility to tobacco products, a proposed advantage of this approach is the reduction of their social acceptability, as well as the limitation of exposure to in-store environmental cues (263). Of note, sales of tobacco products in pharmacies are prohibited in all Canadian provinces except for British Columbia, and sales in universities and colleges are banned in 7 out of the 10 provinces. Other specific venues are banned from selling tobacco in some jurisdictions, such as bars and

restaurants in New Brunswick and Quebec, government buildings in Ontario, and casinos and other gambling venues in Quebec (57).

Given evidence showing a higher smoking prevalence among youth in areas where tobacco retailers are located near schools (130, 135, 143, 264), and the typically strong political support for these measures (262), some jurisdictions have enacted tobacco sales bans in proximity to educational institutions (e.g.: certain municipalities in the United States such as San Francisco and Philadelphia) (57). Although focused on youth, these measures have been shown to be effective in reducing store density, therefore potentially impacting smoking rates in other populations (164). As of 2017, no Canadian jurisdiction had enacted legislation prohibiting tobacco sales within a specified distance of schools (57), therefore constituting a potential strategy to curb smoking among different population groups.

A third strategy, based on its success in reducing harmful alcohol consumption (265) is the enactment of regulations requiring a minimum distance between tobacco retail stores. Although still not widely used, simulation models testing minimum distances ranging from 500 to 1500 feet between stores have shown promising results (266, 267). Furthermore, some authors have proposed that this strategy may have the additional advantage of reducing disproportionate tobacco store concentrations within socioeconomically disadvantaged areas (262).

Another potential strategy to reduce the concentration of tobacco retail is the limitation of the number of outlets allowed to conduct business within a defined geographic area. Two approaches are typically proposed to cap store counts: 1) via restrictions on the absolute number of outlets permitted to sell tobacco in an area, and 2) by establishing limits on their number in proportion to population size. Whereas similar to approaches based on minimum-distance restrictions tobacco retail regulations lag behind those concerning alcohol-selling stores (262), some national and subnational geographic-based restrictions have been enacted. For example, Hungary has regulations in place limiting the number of tobacco retailers to one for every 2000 residents (268).

Also, some commentators have proposed a “sinking-lid” strategy involving retailer number reductions over time (either mandated or via non-renewal of sales licenses) as a complementary

approach to area-based caps on retailers (269-271). As with minimum-distance approaches, different analyses using simulation models suggest that these strategies can be effective in reducing smoking prevalence (266, 272). Finally, an approach seen by some as central to the tobacco endgame (269) (again similar to alcohol-related policy) is the restriction of sales exclusively to tobacco-only stores. This approach has the advantage of making its enforcement and policing easier, however it is likely to meet strong opposition from those with an interest in the commercialization of tobacco products and therefore some believe this strategy may be most suitable to the longer term. Nonetheless, the above-mentioned Hungarian legislation is an example of such regulations (268).

None of the strategies discussed above (distance-based restrictions, limits on tobacco retailers by area, sinking-lid approaches, restricting sales to tobacco-only stores) have been implemented in any Canadian jurisdiction as of late 2017 (57). Whereas detailed analyses will be necessary, in light of studies showing their theoretical impact (188, 267, 272), these strategies warrant further examination. To this end, each approach should be examined individually in terms of its potential to reduce smoking prevalence and compared to the other strategies. Their effects on smoking behaviour could be evaluated using quasi-experimental designs comparing intervention and control areas with different levels of presence and/or density of tobacco retail. Moreover, since many of these strategies have not been applied in the real world, their feasibility, legality, and potential to increase the appeal and presence of black market, contraband and other illegal sales must be also evaluated (163), as well as their acceptability in terms of restrictions on freedom of choice (273). Finally, and even though as proposed in this dissertation residential environments exert a significant influence on smoking behaviour, these strategies should also consider non-residential environments. Failure to do this may reduce the impact of distribution-reduction interventions, as people may still have access and be exposed to tobacco retail stores in other daily activity locations (136). Hence, regulations enacted at the municipal, regional or national level are more likely to be successful.

5.6.3 Outdoor smoking bans as a strategy to reduce smoking prevalence

Results from this dissertation suggest that a higher presence of smoker accommodation facilities may contribute to sustaining smoking among young adults, and provide support to the enactment

of outdoor smoking bans as a potentially effective approach to smoking prevalence reduction. Since changes in legislation concerning smoking in outdoor places have taken place fairly recently, including the enactment of outdoor smoking bans in bars and restaurants in the province of Quebec (57), the impact of this feature on overall smoking prevalence and persistent smoking patterns could be tested as a natural experiment.

Comprehensive indoor smoking bans including hospitality venues have been enacted in many countries in the past decade or so (242). However, whereas modest reductions in smoking intensity and smoking prevalence following these bans have been reported in some studies (151, 152), others point to a mere shift from indoor to outdoor smoking venues such as patios and terraces, with no significant effect on overall smoking rates for the majority of smokers (153). In the same vein, a 2014 paper examining associations between smoking cessation and exposure to smoking in patios and terraces found that smokers exposed to these features were less likely to have made a quit attempt and more likely to have relapsed compared to those not exposed (157).

Bans on smoking in outdoor spaces have received increasing attention from public health stakeholders. These measures, which have initially targeted open spaces/playgrounds in elementary schools and high schools, hospital grounds, and public building entrances, have been progressively extended to patios and other outdoor smoking accommodation facilities in hospitality venues (e.g.: all Canadian provinces except for British Columbia, Manitoba and Saskatchewan have banned smoking in outdoor terraces and patios) (57). More recently, bans on smoking in other public outdoor spaces such as beaches, sports fields and arenas and jogging trails have been adopted by several jurisdictions (57), and further extensions have been proposed (e.g.: bans in all types of parks, sporting areas and playgrounds) (274). Whereas the primary motivation behind these regulations tends to be the protection of non-smokers from exposure to second-hand smoke (242), as discussed previously in this dissertation, a few studies provide evidence of positive associations between outdoor smoking bans and quit attempts and smoking cessation (157, 244).

Nonetheless, in spite of their potential effectiveness these measures are not without controversy (275-278), and could entail negative impacts including an increase in social inequalities and further marginalization of smokers. Regarding the latter, some studies have highlighted higher levels of

stigmatization as a result of extended outdoor smoking bans (277, 279) which in turn may also translate into a reduced access to facilities where smoking is banned, such as outdoor recreation spaces (277). Hence, as is the case with interventions seeking to reduce the availability of tobacco products, although potentially promising, policies seeking to extend outdoor bans should be carefully evaluated using approaches similar to those proposed in the previous section, not only in terms of their potential to reduce smoking prevalence in the general population but also in terms of their ability to reach specific populations (such as young adults), and their potential impact on social inequalities and further marginalization of smokers.

5.7 Conclusion

Despite sustained decreases in smoking prevalence on a global basis, tobacco use is still one of the major preventable risk factors associated with premature mortality and morbidity across populations. Worrisome trends in overall smoking prevalence among young adults, as well as increasing initiation rates require immediate attention from the public health community. This doctoral dissertation provided important insights regarding smoking behaviour patterns in young adults and their potential determinants, and proposed potential avenues to help curb smoking in this age group.

Findings from this thesis highlight the need to extend the examination of smoking outcomes to include distinct behavioural patterns that delve into how tobacco use may progress over time in this age group, and how these patterns may be associated with environmental features in areas where young adults reside. Moreover, this research underscores the need to improve our understanding of the different potential for specific features to influence distinct smoking behaviour patterns, as well as the examination of the spatial scales at which these features may significantly contribute to shape them. Future research in this area should continue to examine how environmental features may influence smoking behaviour patterns not only in young adults but also in other populations. These studies will be essential to the design and implementation of public health policies and interventions seeking to effectively reduce the burden of smoking. Finally, although this dissertation did not examine other young adult health behaviour patterns, its findings point to the importance of their identification and examination, particularly given the increased susceptibility of behavioural changes during this life stage.

BIBLIOGRAPHY

1. Omran A. The Epidemiologic Transition: A Theory of the Epidemiology of Population Change. The Millbank Quarterly. 1971;83(4):731-57.

2. Abel T, McQueen DV. Current and Future Theoretical Foundations for NCDs and Health Promotion. In: McQueen DV, editor. *Global Handbook on Noncommunicable Diseases and Health Promotion*: Springer-Verlag New York; 2013.

3. Danaei G, Ding EL, Mozaffarian D, Taylor B, Rehm J, Murray CJ, et al. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. PLoS Med. 2009;6(4):e1000058.

4. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual Causes of Death in the United States, 2000. JAMA. 2004;291(10):1238-45.

5. *Neighborhoods and Health. 2nd ed*. New York, NY: Oxford University Press; 2018.

6. Diez Roux AV, Mair C. Neighborhoods and health. Ann N Y Acad Sci. 2010;1186:125-45.

7. Macintyre S, Ellaway A. Rediscovering the Role of the Physical and Social Environment. In: Berkman LF, Kawachi I, editors. Social Epidemiology: Oxford University Press; 2000. p. 332-48.

8. *Neighbourhood Effects Research: New Perspectives*. New York, NY: Springer; 2012.

9. *Neighbourhood Structure and Health Promotion*. New York, NY: Springer; 2013.

10. Bernard P, Charafeddine R, Frohlich KL, Daniel M, Kestens Y, Potvin L. Health inequalities and place: a theoretical conception of neighbourhood. Soc Sci Med. 2007;65(9):1839-52.

11. Diez Roux AV. Neighborhoods and health: where are we and were do we go from here? Rev Epidemiol Sante Publique. 2007;55(1):13-21.

12. Duncan DT, Kawachi I. Neighborhoods and Health: A Progress Report. In: Duncan DT, Kawachi I, editors. *Neighborhoods and Health. 2nd ed*. New York, NY: Oxford University Press; 2018.

13. Soja EW. *Seeking Spatial Justice*. Minneapolis, MN: University of Minnesota Press; 2010.

14. World Health Organization. *Our cities, our health, our future: acting on social determinants for health equity in urban settings*. Report to the WHO Commission on Social Determinants of Health from the Knowledge Network on Urban Settings. Geneva, Switzerland; 2008.

15. Feng J, Glass TA, Curriero FC, Stewart WF, Schwartz BS. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place. 2010;16(2):175-90.

16. Safron M, Cislak A, Gaspar T, Luszczynska A. Micro-environmental characteristics related to body weight, diet, and physical activity of children and adolescents: a systematic umbrella review. Int J Environ Health Res. 2011;21(5):317-30.

17. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. Epidemiol Rev. 2007;29:129-43.

18. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth a review. Am J Prev Med. 2011;41(4):442-55.

19. Black JL, Macinko J. Neighborhoods and obesity. Nutr Rev. 2008;66(1):2-20.

20. Howe CJ, Siegel H, Dulin-Keita A. Neighborhood Environments and Sexual Risk Behaviors for HIV Infection Among U.S. Women: A Systematic Review. AIDS Behav. 2017;21(12):3353-65.

21. Leal C, Chaix B. The influence of geographic life environments on cardiometabolic risk factors: a systematic review, a methodological assessment and a research agenda. Obes Rev. 2011;12(3):217-30.

22. Diez Roux AV, Mujahid MS, Hirsch JA, Moore K, Moore LV. The Impact of Neighborhoods on CV Risk. Glob Heart. 2016;11(3):353-63.

23. Malambo P, Kengne AP, De Villiers A, Lambert EV, Puoane T. Built Environment, Selected Risk Factors and Major Cardiovascular Disease Outcomes: A Systematic Review. PLoS One. 2016;11(11):e0166846.

24. Arcaya MC, Tucker-Seeley RD, Kim R, Schnake-Mahl A, So M, Subramanian SV. Research on neighborhood effects on health in the United States: A systematic review of study characteristics. Soc Sci Med. 2016;168:16-29.

25. Openshaw S. The Modifiable Areal Unit Problem. *Concepts and Techniques in Modern Geography*: Geo Books; 1984.

26. Prochaska JO, Velicer WF. The Transtheoretical Model of Health Behavior Change. Am J Health Promot. 1997;12(1):38-48.

27. Baldwin AS, Rothman AJ, Hertel AW, Linde JA, Jeffery RW, Finch EA, et al. Specifying the determinants of the initiation and maintenance of behavior change: an examination of self-efficacy, satisfaction, and smoking cessation. Health Psychol. 2006;25(5):626-34.

28. Rothman AJ. Toward a Theory-Based Analysis of Behavioral Maintenance. Health Psychol. 2000;19(S1):64-9.

29. Baer JS, Kivlahan DR, Blume AW, McKnight P, Marlatt GA. Brief Intervention for Heavy-Drinking College Students: 4-Year Follow-Up and Natural History. Am J Public Health. 2001;91(8):1310-6.

30. Colder CR, Lloyd-Richardson EE, Flaherty BP, Hedeker D, Segawa E, Flay BR, et al. The natural history of college smoking: trajectories of daily smoking during the freshman year. Addict Behav. 2006;31(12):2212-22.

31. Levy DE, Biener L, Rigotti NA. The natural history of light smokers: a population-based cohort study. Nicotine Tob Res. 2009;11(2):156-63.

32. Wetter DW, Kenford SL, Welsch SK, Smith SS, Fouladi RT, Fiore MC, et al. Prevalence and predictors of transitions in smoking behavior among college students. Health Psychol. 2004;23(2):168-77.

33. Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. Medicine & Science in Sports & Exercise. 2000:1601-9.

34. Gordon-Larsen P, Nelson MC, Popkin BM. Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. Am J Prev Med. 2004;27(4):277-83.

35. Lien N, Lytle LA, Klepp KI. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. Prev Med. 2001;33(3):217-26.

36. Rothman AJ, Baldwin AS, Hertel AW. Self-regulation and behavior change: Disentangling behavioral initiation and behavioral maintenance. In: Baumeister R, Vohs K, editors. *Handbook of self regulation: Research, theory, and applications*. New York, NY: Guilford Press; 2004. p. 130-48.

37. Voils CI, Gierisch JM, Yancy WS, Jr., Sandelowski M, Smith R, Bolton J, et al. Differentiating Behavior Initiation and Maintenance: Theoretical Framework and Proof of Concept. Health Educ Behav. 2014;41(3):325-36.

38. Kwasnicka D, Dombrowski SU, White M, Sniehotta F. Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. Health Psychol Rev. 2016:1-20.

39. National Research Council. *Investing in the health and well-being of young adults*: National Academies Press; 2015.

40. Mulye TP, Park MJ, Nelson CD, Adams SH, Irwin CE, Jr., Brindis CD. Trends in adolescent and young adult health in the United States. J Adolesc Health. 2009;45(1):8-24.

41. Stroud C, Walker LR, Davis M, Irwin CE, Jr. Investing in the health and well-being of young adults. J Adolesc Health. 2015;56(2):127-9.

42. Public Health Agency of Canada. Risk Factor Atlas 2013 [Available from: www.phac-aspc.gc.ca/cd-mc/atlas/index-eng.php. Accessed online March 6, 2018.

43. Reid JL, Hammond D, Rynard VL, Madill CL, Burkhalter R. *Tobacco Use in Canada: Patterns and Trends, 2017 Edition*. Waterloo, Canada: Propel Centre for Population Health Impact, University of Waterloo; 2017.

44. Statistics Canada. Canadian Tobacco, Alcohol and Drugs Survey, 2015 (updated) 2016 [Available from: http://www.statcan.gc.ca/daily-quotidien/161109/dq161109b-eng.htm. Accessed online March 6, 2018.

45. Myers MG, Doran NM, Trinidad DR, Wall TL, Klonoff EA. A prospective study of cigarette smoking initiation during college: Chinese and Korean American students. Health Psychol. 2009;28(4):448-56.

46. O'Loughlin JL, Dugas EN, O'Loughlin EK, Karp I, Sylvestre MP. Incidence and determinants of cigarette smoking initiation in young adults. J Adolesc Health. 2014;54(1):26-32 e4.

47. Hammond D. Smoking behaviour among young adults: beyond youth prevention. Tob Control. 2005;14(3):181-5.

48. Bernat DH, Klein EG, Forster JL. Smoking initiation during young adulthood: a longitudinal study of a population-based cohort. J Adolesc Health. 2012;51(5):497-502.

49. Freedman KS, Nelson NM, Feldman LL. Smoking Initiation Among Young Adults in the United States and Canada, 1998-2010: A Systematic Review. Preventing Chronic Disease. 2011.

50. Tjora T, Hetland J, Aaro LE, Wold B, Overland S. Late-onset smokers: how many, and associations with health behaviours and socioeconomic status. Scand J Public Health. 2012;40(6):537-43.

51. Tercyak KP, Rodriguez D, Audrain-McGovern J. High School Seniors' Smoking Initiation and Progression 1 Year After Graduation. Am J Public Health. 2007;97(8):1397-8.

52. Green MP, McCausland KL, Xiao H, Duke JC, Vaiione DM, Heaiton CG. A Closer Look at Smoking Among Young Adults: Where Tobacco Control Should Focus Its Attention. Am J Public Health. 2007;97(8):1427-33.

53. Pampel FC, Krueger PM, Denney JT. Socioeconomic Disparities in Health Behaviors. Annu Rev Sociol. 2010;36:349-70.

54. Pampel FC, Mollborn S, Lawrence EM. Life course transitions in early adulthood and SES disparities in tobacco use. Soc Sci Res. 2014;43:45-59.

55. Backinger CL, Fagan P, Matthews E, Grana R. Adolescent and young adult tobacco prevention and cessation: current status and future directions. Tob Control. 2003;12(Suppl IV):iv46-iv53.

56. Ministère de la santé et des services sociaux. *Le tabagisme chez les jeunes adultes : Rapport du directeur national de santé publique*. 2017.

57. Canadian Cancer Society. *Overview Summary of Federal/Provincial/Territorial Tobacco Control Legislation in Canada*. 2017.

58. Bill 44: An Act to bolster tobacco control, 41st Legislature, Quebec National Assembly, 1st Session. (2015).

59. Sugiyama T, Giles-Corti B, Summers J, du Toit L, Leslie E, Owen N. Initiating and maintaining recreational walking: a longitudinal study on the influence of neighborhood green space. Prev Med. 2013;57(3):178-82.

60. Corder K, Craggs C, Jones AP, Ekelund U, Griffin SJ, van Sluijs E. Predictors of change differ for moderate and vigorous intensity physical activity and for weekdays and weekends: a longitudinal analysis. Int J Behav Nutr Phys Act. 2013;10(69):1-10.

61. Roberto CA, Swinburn B, Hawkes C, Huang TTK, Costa SA, Ashe M, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. The Lancet. 2015;385(9985):2400-9.

62. McCarthy WJ, Mistry R, Lu Y, Patel M, Zheng H, Dietsch B. Density of tobacco retailers near schools: effects on tobacco use among students. Am J Public Health. 2009;99(11):2006-13.

63. Pokorny SB, Jason LA, Schoeny ME. The relation of retail tobacco availability to initiation and continued smoking. J Clin Child Adolesc Psychol. 2003;32(2):193-204.

64. Galster G. On the Nature of Neighbourhood. Urban Studies. 2001;38(12):2111-24.

65. Kwan MP. From place-based to people-based exposure measures. Soc Sci Med. 2009;69(9):1311-3.

66. Spielman SE, Yoo EH. The spatial dimensions of neighborhood effects. Soc Sci Med. 2009;68(6):1098-105.

67. Macintyre S, Ellaway A, Cummins S. Place effects on health: how can we conceptualise, operationalise and measure them? Soc Sci Med. 2002(55):125-39.

68. Messer LC. Invited commentary: Beyond the metrics for measuring neighborhood effects. Am J Epidemiol. 2007;165(8):868-71; discussion 72-3.

69. Baliunas D, Patra J, Rehm J, Popova S, Kaiserman M, Taylor B. Smoking-attributable mortality and expected years of life lost in Canada 2002: Conclusions for prevention and policy. Chronic Diseases in Canada. 2007;27(4):154-62.

70. Statistics Canada. Canadian Community Health Survey: Smokers, by age group, 2017. Table 13-10-0096-10, 2018 [Available from: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1310009601#timeframe. Accessed online March 6, 2018.

71.Johnston LD, O'Malley PM, Bachman JG, Schulenberg JE. Monitoring the Future National Survey Results on Drug Use, 1975-2010: Volume II, College Students and Adults Ages 19–50. Ann Arbor, MI; 2011.

72. US Department of Health and Human Services. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta, GA; 2014.

73. Gagne T, Veenstra G. Trends in smoking initiation in Canada: Does non-inclusion of young adults in tobacco control strategies represent a missed opportunity? Can J Public Health. 2017;108(1):e14-e20.

74. Suls JM, Luger TM, Curry SJ, Mermelstein RJ, Sporer AK, An LC. Efficacy of smoking-cessation interventions for young adults: a meta-analysis. Am J Prev Med. 2012;42(6):655-62.

75. Berrick AJ. The tobacco-free generation proposal. Tob Control. 2013;22 Suppl 1:i22-6.

76. Walters EH, Barnsley K. Tobacco-free generation legislation. Med J Aust. 2015;202(10):509-10.

77. Moon G, Barnett R, Pearce J, Thompson L, Twigg L. The tobacco endgame: The neglected role of place and environment. Health Place. 2018;53:271-8.

78. Azagba S, Baskerville NB, Minaker L. A comparison of adolescent smoking initiation measures on predicting future smoking behavior. Prev Med Rep. 2015;2:174-7.

79. Reidpath DD, Davey TM, Kadirvelu A, Soyiri IN, Allotey P. Does one cigarette make an adolescent smoker, and is it influenced by age and age of smoking initiation? Evidence of association from the U.S. Youth Risk Behavior Surveillance System (2011). Prev Med. 2014;59:37-41.

80. Breslau N, Peterson EL. Smoking Cessation in Young Adults: Age at Initiation of Cigarette Smoking and Other Suspected Influences. Am J Public Health. 1996;86(2):214-20.

81. O'Loughlin J, Gervais A, Dugas E, Meshefedjian G. Milestones in the Process of Cessation Among Novice Adolescent Smokers. Am J Public Health. 2009;99(3):499-504.

82. van Stralen MM, De Vries H, Mudde AN, Bolman C, Lechner L. Determinants of initiation and maintenance of physical activity among older adults: a literature review. Health Psychology Review. 2009;3(2):147-207.

83. Caldeira KM, O'Grady KE, Garnier-Dykstra LM, Vincent KB, Pickworth WB, Arria AM. Cigarette smoking among college students: longitudinal trajectories and health outcomes. Nicotine Tob Res. 2012;14(7):777-85.

84. Hoeppner BB, Bidwell LC, Colby SM, Barnett NP. Smoking patterns and their relationship to drinking among first-year college students. Nicotine Tob Res. 2014;16(6):743-52.

85. Hair E, Bennett M, Williams V, Johnson A, Rath J, Cantrell J, et al. Progression to established patterns of cigarette smoking among young adults. Drug Alcohol Depend. 2017;177:77-83.

86. Lantz PM. Smoking on the rise among young adults: implications for research and policy. Tob Control. 2003;12(S1):i60-i70.

87. Frohlich KL, Corin E, Potvin L. A theoretical proposal for the relationship between context and disease. Sociology of Health & Illness. 2001;23(6):776-97.

88. Frohlich KL, Poland B, Shareck M. Contrasting Entry Points for Intervention in Health Promotion Practice; Situating and Working with Context. In: Rootman I, Dupéré S, Pederson A, O'Neill M, editors. *Health Promotion in Canada: Critical Perspectives on Practice. 3rd ed*. Toronto, Canada: Canadian Scholars' Press Inc.; 2012. p. 102-16.

89. Siahpush M, Borland R, Taylor J, Singh GK, Ansari Z, Serraglio A. The association of smoking with perception of income inequality, relative material well-being, and social capital. Soc Sci Med. 2006;63(11):2801-12.

90. van Lenthe FJ, Mackenbach JP. Neighbourhood and individual socioeconomic inequalities in smoking: the role of physical neighbourhood stressors. J Epidemiol Community Health. 2006;60(8):699-705.

91. Virtanen M, Kivimaki M, Kouvonen A, Elovainio M, Linna A, Oksanen T, et al. Average household income, crime, and smoking behaviour in a local area: the Finnish 10-Town study. Soc Sci Med. 2007;64(9):1904-13.

92. Doku D, Koivusilta L, Rainio S, Rimpela A. Socioeconomic differences in smoking among Finnish adolescents from 1977 to 2007. J Adolesc Health. 2010;47(5):479-87.

93. Federico B, Costa G, Kunst AE. Educational inequalities in initiation, cessation, and prevalence of smoking among 3 Italian birth cohorts. Am J Public Health. 2007;97(5):838-45.

94. Harman J, Graham H, Francis B, Inskip HM, Group SWSS. Socioeconomic gradients in smoking among young women: A British survey. Soc Sci Med. 2006;63(11):2791-800.

95. Lovato C, Watts A, Brown S, Lee D, Sabiston C, Nykiforuk C, et al. School and Community Predictors of Smoking: A Longitudinal Study of Canadian High Schools. Am J Public Health. 2013;103(2):362-8.

96. Turrell G, Hewitt BA, Miller SA. The influence of neighbourhood disadvantage on smoking cessation and its contribution to inequalities in smoking status. Drug Alcohol Rev. 2012;31(5):645-52.

97. ASSS Montreal. Montréal sans tabac: Pour une génération de non-fumeurs. Montreal, Canada: Agence de la santé et des services sociaux de Montréal; 2014.

98. Siahpush M, Jones PR, Singh GK, Timsina LR, Martin J. Association of availability of tobacco products with socio-economic and racial/ethnic characteristics of neighbourhoods. Public Health. 2010;124(9):525-9.

99. Schneider JE, Reid RJ, Peterson NA, Lowe JB, Hughey J. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. Prev Sci. 2005;6(4):319-25.

100. Shortt NK, Tisch C, Pearce J, Mitchell R, Richardson EA, Hill S, et al. A cross-sectional analysis of the relationship between tobacco and alcohol outlet density and neighbourhood deprivation. BMC Public Health. 2015;15:1014.

101. Marsh L, Ajmal A, McGee R, Robertson L, Cameron C, Doscher C. Tobacco retail outlet density and risk of youth smoking in New Zealand. Tob Control. 2015.

102. Galiatsatos P, Kineza C, Hwang S, Pietri J, Brigham E, Putcha N, et al. Neighbourhood characteristics and health outcomes: evaluating the association between socioeconomic status, tobacco store density and health outcomes in Baltimore City. Tob Control. 2017;0(1-6).

103. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics. 2006;117(2):417-24.

104. Wen M, Zhang X, Harris CD, Holt JB, Croft JB. Spatial disparities in the distribution of parks and green spaces in the USA. Annals of Behavioral Medicine. 2013;45(Suppl 1):S18-S27.

105. Powell LM, Slater S, Chaloupka FJ, Harper D. Availability of physical activity–related facilities and neighborhood demographic and socioeconomic characteristics: a national study. Am J Public Health. 2006;96(9):1676-80.

106. Chahine T, Subramanian SV, Levy JI. Sociodemographic and geographic variability in smoking in the U.S.: a multilevel analysis of the 2006-2007 Current Population Survey, Tobacco Use Supplement. Soc Sci Med. 2011;73(5):752-8.

107. Chuang YC, Cubbin C, Ahn D, Winkleby MA. Effects of neighbourhood socioeconomic status and convenience store concentration on individual level smoking. J Epidemiol Community Health. 2005;59(7):568-73.

108. Reijneveld SA. The impact of individual and area characteristics on urban socioeconomic differences in health and smoking. Int J Epidemiol. 1998;27:33-40.

109. Ross CE. Walking, exercising, and smoking: does neighborhood matter? Soc Sci Med. 2000;51:265-74.

110. Datta GD, Subramanian SV, Colditz GA, Kawachi I, Palmer JR, Rosenberg L. Individual, neighborhood, and state-level predictors of smoking among US Black women: a multilevel analysis. Soc Sci Med. 2006;63(4):1034-44.

111. Duncan C, Jones K, Moon G. Smoking and deprivation: are there neighbourhood effects? Soc Sci Med. 1999;48:497-505.

112. Pearce J, Barnett R, Moon G. Sociospatial inequalities in health-related behaviours: Pathways linking place and smoking. Progress in Human Geography. 2012;36(1):3-24.

113. Rogers EM. *Diffusion of innovations*: Simon and Schuster; 2010.

114. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: A multilevel study of collective efficacy. Science. 1997;277(5328):918-24.

115. Kawachi I, Berkman LF. Social cohesion, social capital, and health. In: Berkman LF, Kawachi I, editors. *Social Epidemiology*: Oxford University Press; 2000. p. 174-90.

116. Agyemang C, van Hooijdonk C, Wendel-Vos W, Lindeman E, Stronks K, Droomers M. The association of neighbourhood psychosocial stressors and self-rated health in Amsterdam, The Netherlands. J Epidemiol Community Health. 2007;61(12):1042-9.

117. Alcala HE, Sharif MZ, Albert SL. Social cohesion and the smoking behaviors of adults living with children. Addict Behav. 2016;53:201-5.

118. Aslund C, Nilsson KW. Social capital in relation to alcohol consumption, smoking, and illicit drug use among adolescents: a cross-sectional study in Sweden. Int J Equity Health. 2013;12:33.

119. Fleischer NL, Lozano P, Arillo Santillan E, Reynales Shigematsu LM, Thrasher JF. The impact of neighbourhood violence and social cohesion on smoking behaviours among a cohort of smokers in Mexico. J Epidemiol Community Health. 2015;69(11):1083-90.

120. Lin EY, Witten K, Casswell S, You RQ. Neighbourhood matters: perceptions of neighbourhood cohesiveness and associations with alcohol, cannabis and tobacco use. Drug Alcohol Rev. 2012;31(4):402-12.

121. Lozano P, Fleischer NL, Moore S, Shigematsu LM, Santillan EA, Thrasher JF. Does neighborhood social cohesion modify the relationship between neighborhood social norms and smoking behaviors in Mexico? Health Place. 2016;40:145-52.

122. Patterson JM, Eberly LE, Ding Y, Hargreaves M. Associations of smoking prevalence with individual and area level social cohesion. J Epidemiol Community Health. 2004;58(8):692-7.

123. Sapag JC, Poblete FC, Eicher C, Aracena M, Caneo C, Vera G, et al. Tobacco smoking in urban neighborhoods: exploring social capital as a protective factor in Santiago, Chile. Nicotine Tob Res. 2010;12(9):927-36.

124. Holmes LM, Marcelli EA. Neighborhood social cohesion and smoking among legal and unauthorized Brazilian migrants in metropolitan Boston. J Urban Health. 2014;91(6):1175-88.

125. Brown QL, Milam AJ, Smart MJ, Johnson RM, Linton SL, Furr-Holden CD, et al. Objective and perceived neighborhood characteristics and tobacco use among young adults. Drug Alcohol Depend. 2014;134:370-5.

126. Echeverria S, Diez-Roux AV, Shea S, Borrell LN, Jackson S. Associations of neighborhood problems and neighborhood social cohesion with mental health and health behaviors: the Multi-Ethnic Study of Atherosclerosis. Health Place. 2008;14(4):853-65.

127. Giordano GN, Lindstrom M. The impact of social capital on changes in smoking behaviour: a longitudinal cohort study. Eur J Public Health. 2011;21(3):347-54.

128. Mayne SL, Auchincloss AH, Moore KA, Michael YL, Tabb LP, Echeverria SE, et al. Cross-sectional and longitudinal associations of neighbourhood social environment and smoking behaviour: the multiethnic study of atherosclerosis. J Epidemiol Community Health. 2017;71(4):396-403.

129. Wen M. Social Capital and Adolescent Substance Use: The Role of Family, School, and Neighborhood Contexts. J Res Adolesc. 2017;27(2):362-78.

130. Henriksen L, Feighery EC, Schleicher NC, Cowling DW, Kline RS, Fortmann SP. Is adolescent smoking related to the density and proximity of tobacco outlets and retail cigarette advertising near schools? Prev Med. 2008;47(2):210-4.

131. Lipperman-Kreda S, Mair C, Grube JW, Friend KB, Jackson P, Watson D. Density and proximity of tobacco outlets to homes and schools: relations with youth cigarette smoking. Prev Sci. 2014;15(5):738-44.

132. Marashi-Pour S, Cretikos M, Lyons C, Rose N, Jalaludin B, Smith J. The association between the density of retail tobacco outlets, individual smoking status, neighbourhood socioeconomic status and school locations in New South Wales, Australia. Spat Spatiotemporal Epidemiol. 2015;12:1-7.

133. Novak SP, Reardon SF, Raudenbush SW, Buka SL. Retail Tobacco Outlet Density and Youth Cigarette Smoking: A Propensity-Modeling Approach. Am J Public Health. 2006;96:670-6.

134. Pearce J, Rind E, Shortt N, Tisch C, Mitchell R. Tobacco Retail Environments and Social Inequalities in Individual-Level Smoking and Cessation Among Scottish Adults. Nicotine Tob Res. 2016;18(2):138-46.

135. Scully M, McCarthy M, Zacher M, Warne C, Wakefield M, White V. Density of tobacco retail outlets near schools and smoking behaviour among secondary school students. Australian and New Zealand Journal of Public Health. 2013;37(6):574-8.

136. Shareck M, Kestens Y, Vallee J, Datta G, Frohlich KL. The added value of accounting for activity space when examining the association between tobacco retailer availability and smoking among young adults. Tob Control. 2015.

137. Cantrell J, Anesetti-Rothermel A, Pearson JL, Xiao H, Vallone D, Kirchner TR. The impact of the tobacco retail outlet environment on adult cessation and differences by neighborhood poverty. Addiction. 2015;110(1):152-61.

138. Chaiton M, Mecredy G, Rehm J, Samokhvalov AV. Tobacco retail availability and smoking behaviours among patients seeking treatment at a nicotine dependence treatment clinic. Tob Induc Dis. 2014;12(1):19.

139. Halonen JI, Kivimaki M, Kouvonen A, Pentti J, Kawachi I, Subramanian SV, et al. Proximity to a tobacco store and smoking cessation: a cohort study. Tob Control. 2014;23(2):146-51.

140. Pulakka A, Halonen JI, Kawachi I, Pentti J, Stenholm S, Jokela M, et al. Association Between Distance From Home to Tobacco Outlet and Smoking Cessation and Relapse. JAMA Intern Med. 2016;176(10):1512-9.

141. Cantrell J, Pearson JL, Anesetti-Rothermel A, Xiao H, Kirchner TR, Vallone D. Tobacco Retail Outlet Density and Young Adult Tobacco Initiation. Nicotine Tob Res. 2016;18(2):130-7.

142. Johns M, Sacks R, Rane M, Kansagra SM. Exposure to tobacco retail outlets and smoking initiation among New York City adolescents. J Urban Health. 2013;90(6):1091-101.

143. Chan WC, Leatherdale ST. Tobacco retailer density surrounding schools and youth smoking behaviour: a multi-level analysis. Tobacco Induced Diseases. 2011;9(9).

144. Chaiton MO, Mecredy G, Cohen J. Tobacco retail availability and risk of relapse among smokers who make a quit attempt: a population based cohort study. Tob Control. 2017(0):1-7.

145. Reitzel LR, Cromley EK, Li Y, Cao Y, Dela Mater R, Mazas CA, et al. The effect of tobacco outlet density and proximity on smoking cessation. Am J Public Health. 2011;101(2):315-20.

146. Han T, Alexander M, Niggebrugge A, Hollands GJ, Marteau TM. Impact of tobacco outlet density and proximity on smoking cessation: a longitudinal observational study in two English cities. Health Place. 2014;27:45-50.

147. Mennis J, Mason M, Way T, Zaharakis N. The role of tobacco outlet density in a smoking cessation intervention for urban youth. Health Place. 2016;38:39-47.

148. Pearce J, Hiscock R, Moon G, Barnett R. The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour. J Epidemiol Community Health. 2009;63(1):69-77.

149. Fleischer NL, Lozano P, Wu Y-H, Hardin JW, Meng G, Liese AD, et al. Disentangling the roles of point-of-sale ban, tobacco retailer density and proximity on cessation and relapse among a cohort of smokers: findings from ITC Canada Survey. Tobacco Control. 2018:tobaccocontrol-2017-054081.

150. Kirchner TR, Cantrell J, Anesetti-Rothermel A, Ganz O, Vallone DM, Abrams DB. Geospatial exposure to point-of-sale tobacco: real-time craving and smoking-cessation outcomes. Am J Prev Med. 2013;45(4):379-85.

151. Hargreaves K, Amos A, Highet G, Martin C, Platt S, Ritchie D, et al. The social context of change in tobacco consumption following the introduction of 'smokefree' England legislation: a qualitative, longitudinal study. Soc Sci Med. 2010;71(3):459-66.

152. Pieroni L, Chiavarini M, Minelli L, Salmasi L. The role of anti-smoking legislation on cigarette and alcohol consumption habits in Italy. Health Policy. 2013;111(2):116-26.

153. Kennedy RD, Behm I, Craig L, Thompson ME, Fong GT, Guignard R, et al. Outdoor smoking behaviour and support for outdoor smoking restrictions before and after France's national smoking ban. Eur J Public Health. 2012;22 Suppl 1:29-34.

154. Klein EG, Forster JL, Erickson DJ, Lytle LA, Schillo B. The relationship between local clean indoor air policies and smoking behaviours in Minnesota youth. Tob Control. 2009;18(2):132-7.

155. Ashley M, Saunders P, Mullard G, Prasad K, Mariner D, Williamson J, et al. Smoking intensity before and after introduction of the public place smoking ban in Scotland. Regul Toxicol Pharmacol. 2011;61(Suppl 3):S60-5.

156. Ritchie D, Amos A, Martin C. Public places after smoke-free--a qualitative exploration of the changes in smoking behaviour. Health Place. 2010;16(3):461-9.

157. Chaiton M, Diemert L, Zhang B, Kennedy RD, Cohen JE, Bondy SJ, et al. Exposure to smoking on patios and quitting: a population representative longitudinal cohort study. Tob Control. 2016;25(1):83-8.

158. Ghenadenik AE, Frohlich KL, Gauvin L. Beyond Smoking Prevalence: Exploring the Variability of Associations between Neighborhood Exposures across Two Nested Spatial Units and Two-Year Smoking Trajectory among Young Adults. Int J Environ Res Public Health. 2016;13(1).

159. Kearns A, Mason P. Regeneration, relocation and health behaviours in deprived communities. Health Place. 2015;32:43-58.

160. Blackman T, Harvey J, Lawrence M, Simon A. Neighbourhood renewal and health: evidence from a local case study. Health Place. 2001;7:93-103.

161. Bond L, Egan M, Kearns A, Clark J, Tannahill C. Smoking and intention to quit in deprived areas of Glasgow: is it related to housing improvements and neighbourhood regeneration because of improved mental health? J Epidemiol Community Health. 2013;67(4):299-304.

162. Stock C, Ellaway A. Neighbourhood Structure and Health Promotion: An Introduction. In: Stock C, Ellaway A, editors. *Neighbourhood Structure and Health Promotion*. New York, NY: Springer; 2013. p. 1-7.

163. McDaniel PA, Smith EA, Malone RE. The tobacco endgame: a qualitative review and synthesis. Tob Control. 2016;25(5):594-604.

164. Pearson AL, van der Deen FS, Wilson N, Cobiac L, Blakely T. Theoretical impacts of a range of major tobacco retail outlet reduction interventions: modelling results in a country with a smoke-free nation goal. Tob Control. 2015;24(e1):e32-8.

165. Algren MH, Bak CK, Berg-Beckhoff G, Andersen PT. Health-Risk Behaviour in Deprived Neighbourhoods Compared with Non-Deprived Neighbourhoods: A Systematic Literature Review of Quantitative Observational Studies. PLoS One. 2015;10(10):e0139297.

166. Finan LJ, Lipperman-Kreda S, Abadi M, Grube JW, Kaner E, Balassone A, et al. Tobacco outlet density and adolescents' cigarette smoking: a meta-analysis. Tob Control. 2018.

167. Gwon SH, DeGuzman PB, Kulbok PA, Jeong S. Density and Proximity of Licensed Tobacco Retailers and Adolescent Smoking. J Sch Nurs. 2017;33(1):18-29.

168. Robertson L, McGee R, Marsh L, Hoek J. A systematic review on the impact of point-of-sale tobacco promotion on smoking. Nicotine Tob Res. 2015;17(1):2-17.

169. Lovato C, Watts A, Stead LF. Impact of tobacco advertising and promotion on increasing adolescent smoking behaviours. Cochrane Database of Systematic Reviews. 2011(10).

170. Germain D, McCarthy M, Wakefield M. Smoker sensitivity to retail tobacco displays and quitting: a cohort study. Addiction. 2010;105(1):159-63.

171. Siahpush M, Shaikh RA, Smith D, Hyland A, Cummings KM, Kessler AS, et al. The Association of Exposure to Point-of-Sale Tobacco Marketing with Quit Attempt and Quit Success: Results from a Prospective Study of Smokers in the United States. Int J Environ Res Public Health. 2016;13(2):203.

172. Riva M, Gauvin L, Barnett TA. Toward the next generation of research into small area effects on health: a synthesis of multilevel investigations published since July 1998. J Epidemiol Community Health. 2007;61(10):853-61.

173. Root ED. Moving Neighborhoods and Health Research Forward: Using Geographic Methods to Examine the Role of Spatial Scale in Neighborhood Effects on Health. Ann Assoc Am Geogr. 2012;102(5):986-95.

174. Gauvin L, Robitaille E, Riva M, McLaren L, Dassa C, Potvin L. Conceptualizing and Operationalizing Neighbourhoods: The Conundrum of Identifying Territorial Units. Can J Public Health. 2007;98(S1):S18-S26.

175. Jones AP, van Sluijs EM, Ness AR, Haynes R, Riddoch CJ. Physical activity in children: does how we define neighbourhood matter? Health Place. 2010;16(2):236-41.

176. Schaefer-McDaniel N, Caughy MO, O'Campo P, Gearey W. Examining methodological details of neighbourhood observations and the relationship to health: a literature review. Soc Sci Med. 2010;70(2):277-92.

177. Diez Roux AV. Investigating Neighborhood and Area Effects on Health. Am J Public Health. 2001;91(11):1783-9.

178. Feng J, Glass TA, Curriero FC, Stewart WF, Schwartz BS. The built environment and obesity: A systematic review of the epidemiologic evidence. Health & Place. 2010;16(2):175-90.

179. O'Campo P. Invited Commentary: Advancing Theory and Methods for Multilevel Models of Residential Neighborhoods and Health. American Journal of Epidemiology. 2003;157(1):9-13.

180. Paul CL, Mee KJ, Judd TM, Walsh RA, Tang A, Penman A, et al. Anywhere, anytime: retail access to tobacco in New South Wales and its potential impact on consumption and quitting. Soc Sci Med. 2010;71(4):799-806.

181. Guo JY, Bhat CR. Operationalizing the concept of neighborhood: Application to residential location choice analysis. Journal of Transport Geography. 2007;15(1):31-45.

182. Osypuk T, Galea S. What Level Macro? Choosing Appropriate Levels to Assess How Place Influences Population Health. In: Galea S, editor. *Macrosocial determinants of population health*. New York, NY: Springer; 2007.

183. Stafford M, Duke-Williams O, Shelton N. Small area inequalities in health: are we underestimating them? Soc Sci Med. 2008;67(6):891-9.

184. Schuurman N, Bell N, Dunn JR, Oliver L. Deprivation indices, population health and geography: an evaluation of the spatial effectiveness of indices at multiple scales. J Urban Health. 2007;84(4):591-603.

185. Miles R. Neighborhood disorder and smoking: findings of a European urban survey. Soc Sci Med. 2006;63(9):2464-75.

186. Shareck M, Ellaway A. Neighbourhood crime and smoking: the role of objective and perceived crime measures. BMC Public Health. 2011;11:930.

187. Mmari K, Lantos H, Blum RW, Brahmbhatt H, Sangowawa A, Yu C, et al. A global study on the influence of neighborhood contextual factors on adolescent health. J Adolesc Health. 2014;55(6 Suppl):S13-20.

188. Ma P, Businelle MS, Balis DS, Kendzor DE. The influence of perceived neighborhood disorder on smoking cessation among urban safety net hospital patients. Drug Alcohol Depend. 2015;156:157-61.

189. Wong D. The Modifiable Areal Unit Problem (MAUP). In: Fotheringham AS, Rogerson PA, editors. *The SAGE Handbook of Spatial Analysis*. London, UK: SAGE Publications; 2009. p. 105-23.

190. Vallée J, Shareck M. Re: "Examination of how neighbourhood definition influences measurements of youths' access to tobacco retailers: a methodological note on spatial misclassification". Am J Epidemiol. 2014;179(5):660-1.

191. Hui C. A Bayesian Solution to the Modifiable Areal Unit Problem. In: Hassanien A, Abraham A, Herrera F, editors. *Foundations of Computational Intelligence Volume 2: Approximate Reasoning*. Berlin, Germany: Springer; 2009. p. 175-96.

192. Coulton CJ, Korbin J, Chan T, Su M. Mapping Residents' Perceptions of Neighborhood Boundaries: A Methodological Note. Am J Community Psychology. 2001;29(2):371-83.

193. Vallee J, Le Roux G, Chauvin P. Quartiers et Effets de Quartier: Analyse de la Variabilité de la Taille des Quartiers Perçus Dans l'Agglomération Parisienne. Annales de Géographie. 2016;2(708):119-42.

194. Chaix B, Merlo J, Evans D, Leal C, Havard S. Neighbourhoods in eco-epidemiologic research: delimiting personal exposure areas. A response to Riva, Gauvin, Apparicio and Brodeur. Soc Sci Med. 2009;69(9):1306-10.

195. Shinn M, Toohey SM. Community Contexts of Human Welfare. Annual Review of Psychology. 2003;54(1):427-59.

196. Merlo J, Ohlsson H, Lynch KF, Chaix B, Subramanian SV. Individual and collective bodies: using measures of variance and association in contextual epidemiology. J Epidemiol Community Health. 2009;63(12):1043-8.

197. Spielman SE, Yoo E-H, Linkletter C. Neighborhood Contexts, Health, and Behavior: Understanding the Role of Scale and Residential Sorting. Environment and Planning B: Planning and Design. 2013;40(3):489-506.

198. Chappell NL, Funk LM, Allan D. Defining Community Boundaries in Health Promotion Research. Am J Health Promot. 2006;21(2):119-26.

199. Lebel A, Pampalon R, Villeneuve PY. A multi-perspective approach for defining neighbourhood units in the context of a study on health inequalities in the Quebec City region. International Journal of Health Geographics. 2007;6(1):27.

200. Chaix B. Geographic life environments and coronary heart disease: a literature review, theoretical contributions, methodological updates, and a research agenda. Annu Rev Public Health. 2009;30:81-105.

201. Basta LA, Richmond TS, Wiebe DJ. Neighborhoods, daily activities, and measuring health risks experienced in urban environments. Soc Sci Med. 2010;71(11):1943-50.

202. Vallée J, Le Roux G, Chaix B, Kestens Y, Chauvin P. The 'constant size neighbourhood trap' in accessibility and health studies. Urban Studies. 2014;52(2):338-57.

203. Cummins S. Commentary: investigating neighbourhood effects on health--avoiding the 'local trap'. Int J Epidemiol. 2007;36(2):355-7.

204. Kwan M-P. How GIS can help address the uncertain geographic context problem in social science research. Annals of GIS. 2012;18(4):245-55.

205. Statistics Canada. Census Dictionary: Census Tract (CT) 2016 [Available from: https://www12.statcan.gc.ca/census-recensement/2016/ref/dict/geo013-eng.cfm. Accessed online November 13, 2018

206. Shinn M, Toohey SM. Community contexts of human welfare. Annu Rev Psychol. 2003;54:427-59.

207. Statistics Canada. Census Dictionary: Dissemination Area (DA) 2015 [Available from: https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo021-eng.cfm. Accessed online November 13, 2018.

208. Pampalon R, Raymond G. A Deprivation Index for Health and Welfare Planning in Quebec. 2000;21(3).

209. Pampalon R, Hamel D, Gamache P, Simpson A, Philibert D. Validation of a deprivation index for public health: a complex exercise illustrated by the Quebec index. Chronic Diseases and Injuries in Canada. 2014;34(1):12-22.

210. Pampalon R, Hamel D, Gamache P, Philibert D, Raymond G, Simpson A. An Area-based Material and Social Deprivation Index for Public Health in Québec and Canada. Can J Public Health. 2012;103(S2):S17-S22.

211. Frohlich KL, Shareck M, Vallee J, Abel T, Agouri R, Cantinotti M, et al. Cohort Profile: The Interdisciplinary Study of Inequalities in Smoking (ISIS). Int J Epidemiol. 2015.

212. Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal. Les voisinages de Montréal: Gouvernement du Québec; 2018 [Available from: https://emis.santemontreal.qc.ca/fileadmin/emis/Outil/Atlas/carte_pdf/decoupages/voisinage.pdf. Accessed online October 23, 2018

213. Santé et Services sociaux Québec. Réorganisation du réseau 2018 [Available from: http://www.msss.gouv.qc.ca/reseau/reorganisation/. Accessed online April 4, 2018

214. Direction régionale de santé publique du CIUSSS du Centre-Sud-de-l'Île-de-Montréal. Les territoires de CSSS et CIUSSS à Montréal: Gouvernement du Québec; 2018 [Available from: https://emis.santemontreal.qc.ca/fileadmin/emis/Outil/Atlas/carte_pdf/decoupages/CIUSSS_CSSS_2015_04.pdf. Accessed online October 23, 2018

215. CRCHUM. 2013 [Available from: http://megaphone.crchum.qc.ca/geonetwork/srv/en/main.home. Accessed online October 5, 2015.

216. DMTI Spatial Inc. Enhanced Points of Interest v.3. Markham, Canada. 2011.

217. Clary C, Kestens Y. Field validation of secondary data sources: A novel measure of representativity applied to a Canadian food outlet database. Int J Behav Nutr Phys Act. 2013;10:1-9.

218. Shareck M, Dassa C, Frohlich KL. Improving the measurement of neighbourhood characteristics through systematic observation: inequalities in smoking as a case study. Health Place. 2012;18(3):671-82.

219. Dierker L, He J, Kalaydjian A, Swendsen J, Degenhardt L, Glantz M, et al. The importance of timing of transitions for risk of regular smoking and nicotine dependence. Ann Behav Med. 2008;36(1):87-92.

220. Dierker L, Swendsen J, Rose J, He J, Merikangas K, Tobacco Etiology Research N. Transitions to regular smoking and nicotine dependence in the Adolescent National Comorbidity Survey (NCS-A). Ann Behav Med. 2012;43(3):394-401.

221. Zhan W, Dierker LC, Rose JS, Selya A, Mermelstein RJ. The natural course of nicotine dependence symptoms among adolescent smokers. Nicotine Tob Res. 2012;14(12):1445-52.

222. Health Canada. Canadian Tobacco, Alcohol and Drugs Survey (CTADS): 2017 definitions [Available from: https://www.canada.ca/en/health-canada/services/canadian-tobacco-alcohol-drugs-survey/2017-summary/2017-definitions.html. Accessed online November 28, 2018.

223. Braveman P, Cubbin C, Egerter S, Chideya S, Marchi KS, Metzler M, et al. Socioeconomic Status in Health Research: One Size Does Not Fit All. JAMA. 2005;294(22):2879-88.

224. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60(1):7-12.

225. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 2). J Epidemiol Community Health. 2006;60(2):95-101.

226. Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. Annu Rev Public Health. 2011;32:381-98.

227. Blakely T, Subramanian SV. Multilevel Studies. In: Oakes JM, Kaufman J, editors. *Methods in Social Epidemiology*. San Francisco, CA: Jossey-Bass; 2006. p. 316-40.

228. Tabachnick BG, Fidell LS. *Using Multivariate Statistics. 6th ed*. Boston, MA: Pearson Education; 2013.

229. Raudenbush SW, Bryk AS. *Hierarchical linear models: applications and data analysis methods. 2nd ed*: Sage Publications; 2002.

230. Corsi DJ, Boyle MH, Lear SA, Chow CK, Teo KK, Subramanian SV. Trends in smoking in Canada from 1950 to 2011: progression of the tobacco epidemic according to socioeconomic status and geography. Cancer Causes Control. 2014;25:45-57.

231. Institute of Medicine and National Research Council. *Investing in the Health and Well-Being of Young Adults*. Washington, DC: The National Academies Press; 2015.

232. VanKim NA, Laska MN, Ehlinger E, Lust K, Story M. Understanding young adult physical activity, alcohol and tobacco use in community colleges and 4-year post-secondary institutions: A cross-sectional analysis of epidemiological surveillance data. BMC Public Health. 2010;10(208).

233. Nelson MC, Story M, Larson NI, Neumark-Sztainer D, Lytle LA. Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. Obesity (Silver Spring). 2008;16(10):2205-11.

234. Racette SB, Deusinger SS, Strube MJ, Highstein GR, Deusinger RH. Weight changes, exercise, and dietary patterns during freshman and sophomore years of college. J Am Coll Health. 2005;53(6):245-51.

235. Ben-Shlomo Y, Kuh D. *A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. 2nd ed*. New York, NY: Oxford University Press; 2004.

236. Hiscock R, Bauld L, Amos A, Fidler JA, Munafo M. Socioeconomic status and smoking: a review. Ann N Y Acad Sci. 2012;1248:107-23.

237. Wellman RJ, Dugas EN, Dutczak H, O'Loughlin EK, Datta GD, Lauzon B, et al. Predictors of the Onset of Cigarette Smoking: A Systematic Review of Longitudinal Population-Based Studies in Youth. Am J Prev Med. 2016.

238. Burton S, Hoek J, Nesbit P, Khan A. "Smoking is bad, it's not cool…yet I'm still doing it": Cues for tobacco consumption in a 'dark' market. Journal of Business Research. 2015;68(10):2067-74.

239. Burton S, Spanjaard D, Hoek J. An investigation of tobacco retail outlets as a cue for smoking. Australasian Marketing Journal (AMJ). 2013;21(4):234-9.

240. Trotter L, Wakefield M, Borland R. Socially cued smoking in bars, nightclubs, and gaming venues: a case for introducing smoke-free policies. Tob Control. 2002;11:300-4.

241. Rooke C, Amos A, Highet G, Hargreaves K. Smoking spaces and practices in pubs, bars and clubs: young adults and the English smokefree legislation. Health Place. 2013;19:108-15.

242. Hyland A, Barnoya J, Corral JE. Smoke-free air policies: past, present and future. Tob Control. 2012;21(2):154-61.

243. American Nonsmokers' Rights Foundation. Municipalities with Smokefree Outdoor Dining and Bar Patio Laws Enacted as of October 1, 2018 2018 [Available from: https://no-smoke.org/wp-content/uploads/pdf/SmokefreeOutdoorDining.pdf. Accessed online November 2, 2018.

244. Nagelhout GE, de Vries H, Boudreau C, Allwright S, McNeill A, van den Putte B, et al. Comparative impact of smoke-free legislation on smoking cessation in three European countries. Eur J Public Health. 2012;22 Suppl 1:4-9.

245. Office of Disease Prevention and Health Promotion. *Tobacco Life Stages and Determinants* Washington, DC: U.S. Department of Health and Human Services; 2014 [Available from: https://www.healthypeople.gov/2020/leading-health-indicators/2020-lhi-topics/Tobacco/determinants. Accessed online April 15, 2019.

246. Patrick DL, Cheadle A, Thompson DC, Diehr P, Koepsell T, Kinne S. The Validity of Self-Reported Smoking: A Review and Meta-Analysis. Am J Public Health. 1994;84(7):1086-93.

247. Wong SL, Shields M, Leatherdale S, Malaison E, Hammond D. Assessment of validity of self-reported smoking status. Health Reports. 2012;23(1):1-7.

248. Gagne T, Ghenadenik AE. Rethinking the relationship between socioeconomic status and health: Challenging how socioeconomic status is currently used in health inequality research. Scand J Public Health. 2018;46(1):53-6.

249. Kwan MP. Beyond Space (As We Knew It): Toward Temporally Integrated Geographies of Segregation, Health, and Accessibility. Annals of the Association of American Geographers. 2013;103(5):1078-86.

250. Matthews SA, Yang TC. Spatial Polygamy and Contextual Exposures (SPACEs): Promoting Activity Space Approaches in Research on Place and Health. Am Behav Sci. 2013;57(8):1057-81.

251. Perchoux C, Chaix B, Cummins S, Kestens Y. Conceptualization and measurement of environmental exposure in epidemiology: accounting for activity space related to daily mobility. Health Place. 2013;21:86-93.

252. Health Canada. *Seizing the Opportunity: The Future of Tobacco Control in Canada*. Ottawa, Canada; 2017. Report No.: H149-5/2017E.

253. Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System (BRFSS) 2018 [Available from: https://www.cdc.gov/brfss/index.html. Accessed online December 7, 2018.

254. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey (NHANES) 2018 [Available from: https://www.cdc.gov/nchs/nhanes/index.htm. Accessed online December 7, 2018.

255. Public Health Agency of Canada. The Canadian Chronic Disease Surveillance System – An Overview 2018 [Available from: https://www.canada.ca/en/public-health/services/publications/canadian-chronic-disease-surveillance-system-factsheet.html. Accessed online December 7, 2018.

256. Institute of Medicine. *A Nationwide Framework for Surveillance of Cardiovascular and Chronic Lung Diseases*. Washington, DC: The National Academies Press; 2011.

257. University of Alabama at Birmingham. Coronary Artery Risk Development in Young Adults (CARDIA) 2018 [Available from: https://www.cardia.dopm.uab.edu/. Accessed online December 7, 2018.

258. Centre for Longitudinal Studies. Millennium Cohort Study 2018 [Available from: https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/. Accessed online December 7, 2018.

259. He Y, Shang C, Huang J, Cheng KW, Chaloupka FJ. Global evidence on the effect of point-of-sale display bans on smoking prevalence. Tob Control. 2018.

260. Cohen JE, Anglin L. Outlet density: a new frontier for tobacco control. Addiction. 2009;104(1):2-3.

261. Smyth C, Freeman B, Maag A. Tobacco retail regulation: the next frontier in tobacco control? Public Health Research & Practice. 2015;25(3).

262. Ackerman A, Etow A, Bartel S, Ribisl KM. Reducing the Density and Number of Tobacco Retailers: Policy Solutions and Legal Issues. Nicotine Tob Res. 2017;19(2):133-40.

263. McDaniel PA, Malone RE. Why California retailers stop selling tobacco products, and what their customers and employees think about it when they do: case studies. BMC Public Health. 2011;11(848).

264. Leatherdale ST, Strath JM. Tobacco Retailer Density Surrounding Schools and Cigarette Access Behaviors Among Underage Smoking Students. Ann Behav Med. 2007;33(1):105-11.

265. Ashe M, Jernigan D, Kline R, Galaz R. Land Use Planning and the Control of Alcohol, Tobacco, Firearms, and Fast Food Restaurants. Am J Public Health. 2003;93(9):1404-8.

266. Luke DA, Hammond RA, Combs T, Sorg A, Kasman M, Mack-Crane A, et al. Tobacco Town: Computational Modeling of Policy Options to Reduce Tobacco Retailer Density. Am J Public Health. 2017;107(5):740-6.

267. Myers AE, Hall MG, Isgett LF, Ribisl KM. A comparison of three policy approaches for tobacco retailer reduction. Prev Med. 2015;74:67-73.

268. Monshouwer K, Verdurmen J, Ketelaars J, van Laar MW. *Points of sale of tobacco products: Synthesis of scientific and practice-based knowledge on the impact of reducing the number of points of sale and restrictions on tobacco product displays*. Utrecht, Netherlands: Trimbos Institute, Netherlands Institute for Mental Health and Addiction; 2014.

269. Robertson L, Marsh L, Hoek J, McGee R. New Zealand tobacco control experts' views towards policies to reduce tobacco availability. NZ Med Journal. 2017;130(1456):27-35.

270. Wilson N, Thomson GW, Edwards R, Blakely T. Potential advantages and disadvantages of an endgame strategy: a 'sinking lid' on tobacco supply. Tob Control. 2013;22 Suppl 1:i18-21.

271. Thomson G, Wilson N, Blakely T, Edwards R. Ending appreciable tobacco use in a nation: using a sinking lid on supply. Tob Control. 2010;19(5):431-5.

272. van der Deen FS, Wilson N, Cleghorn CL, Kvizhinadze G, Cobiac LJ, Nghiem N, et al. Impact of five tobacco endgame strategies on future smoking prevalence, population health and health system costs: two modelling studies to inform the tobacco endgame. Tob Control. 2017:1-9.

273. Bates C. The Tobacco Endgame: A critique of policy proposals aimed at ending tobacco use. 2015.

274. Dubray J, Borland T, Chaiton M, Schwartz R. *Evaluation of the Smoke-Free Ontario Act Outdoor Smoking Regulation*. Toronto, ON: Ontario Tobacco Research Unit; 2017.

275. Bayer R, Bachynski KE. Banning smoking in parks and on beaches: science, policy, and the politics of denormalization. Health Aff (Millwood). 2013;32(7):1291-8.

276. Chapman S. Should smoking in outside public spaces be banned? No. BMJ. 2008;337:a2804.

277. Pederson A, Okoli CT, Hemsing N, O'Leary R, Wiggins A, Rice W, et al. Smoking on the margins: a comprehensive analysis of a municipal outdoor smoke-free policy. BMC Public Health. 2016;16(852).

278. Colgrove J, Bayer R, Bachynski KE. Nowhere Left to Hide? The Banishment of Smoking from Public Spaces. N Engl J Med. 2011;364(25):2375-7.

279. Bell K, McCullough L, Salmon A, Bell J. 'Every space is claimed': smokers' experiences of tobacco denormalisation. Sociol Health Illn. 2010;32(6):914-29.

APPENDIX I: ISIS Information Letters and Consent Forms

PRÉNOM NOM
ADRESSE
VILLE, PROVINCE
CODE POSTAL

Invitation to participate in the ISIS project on Health and Neighbourhoods

Hello,

We are contacting you today because you are one of 6,000 young Montrealer's selected to participate in the ISIS project.

The ISIS project is a study being carried out by the University of Montreal to examine the link between neighbourhoods and health in young Montrealers between the ages of 18 and 25. By taking part in this study, you will be invited to complete a questionnaire on different aspects of your life, such as the neighbourhood where you live, your cigarette consumption, your social network, your work and your studies. Thanks to your participation we will be able to find strategies to improve our city's different neighbourhoods for the benefit of everyone living here.

If you accept being part of the ISIS family, we will ask you to complete an online questionnaire at the secure website www.isis-montreal.ca. If you have no Internet connection at home, you can go to your neighbourhood library to respond online.

To access the online questionnaire, you will need to enter the following user code:

User code: TOKEN

This user code is unique and valid for one time only. The online questionnaire is fully secured by the SSL protocol, used by many banking institutions, and we have taken every measure to make sure your information is kept confidential.

If you prefer, you also have the option of: filling out a paper copy of the questionnaire yourself; filling it out over the phone with a member of our team; or filling it out during a face-to-face interview at the time and place of your choice. If you wish to use one of these non-Internet options, feel free to contact us by phone at [redacted] or by email at [redacted]. We will be happy to talk with you!

To thank you for your participation, once you have completed the questionnaire, we will send you compensation in the form of a $10 gift certificate redeemable at either iTunes, Renaud-Bray or Cineplex Odeon. You will be asked to indicate which gift certificate you prefer at the end of the questionnaire.

In order to know if there have been any changes in your neighbourhood or your health, we will contact you again in two years to ask you to complete a questionnaire similar to this one. In the meantime, we will be sending you news about the ISIS project. On your end, don't hesitate to visit the website **www.isis-montreal.ca** to find all kinds of information about the project.

If you have questions about the ISIS project or about your involvement in the study, we invite you to look at the frequently asked questions (FAQ) on our website (www.isis-montreal.ca/FAQ). You can also contact the project coordinators at the phone number or email address below. They will be happy to answer any of your questions.

Michael Cantinotti or Rowena Agouri, ISIS project coordinators:

☎ [redacted]
💻 [redacted]

Many thanks for reading this letter, and welcome to the ISIS project!

Katherine L. Frohlich	*Michael Cantinotti*	*Rowena Agouri*
Principal Investigator	*Coordinator*	*Assistant Coordinator*

Consent form

ISIS – Health and Neighbourhoods

Principal Investigator :

Katherine L. Frohlich
[redacted]
Université de Montréal

[redacted]

Co-Investigators :

Thomas Abel, Michael Cantinotti, Mark Daniel, Clément Dassa, Geetanjali Datta, Yan Kestens, Bernard-Simon Leclerc, Jennifer O'Loughlin, Louise Potvin, Martine Shareck

Objective of the project: The aim of the ISIS study is to examine the link between young Montrealers' health and their neighbourhoods. We also want to understand why tobacco use remains high in low-income groups and what it is, in a neighbourhood, that most influences differences related to tobacco use. You are one of 6,000 Montrealers who have been invited to take part in this University of Montreal study.

How it works: If you agree to take part in the ISIS study, we will ask you to fill out a questionnaire on different aspects of your life, such as the neighbourhood in which you live, your cigarette consumption, your social network, your work and your studies. This questionnaire will take about 20 minutes to complete. You can choose to fill out the questionnaire by: 1. completing it online on a password-protected website; 2. filling out a paper version yourself; 3. filling it out over the phone with one of our team members or; 4. doing a face-to-face interview at the time and place of your choice. Once you have submitted your completed questionnaire, we will send you a $10 gift certificate redeemable at the retailer of your choice: iTunes, Renaud-Bray or Cineplex Odeon. In two years, in order to find out if there have been any changes in your neighbourhood and your health, we will contact you again to ask you to complete a similar questionnaire. Your continued participation is extremely important. For this reason, someone in charge of interviews might contact you at home, by phone or in person as part of this study at a future date.

articipation: We obtained your contact information from the Quebec Health Insurance Board (*Régie de l'assurance-maladie du Québec*), with authorization from Quebec's Commission on Access to Information. Your participation in the ISIS study is entirely voluntary. You can choose to participate or not. If any of the questions make you uncomfortable, or if you feel they might cause you psychological harm, you can also refuse to answer them. If you do not agree to participate, or decide to withdraw from the study at any time, you do not need to give us your reason and there will be no negative consequences. You may withdraw from the study at any time by contacting the study's coordinator: Rowena Agouri, at [redacted] or by email at [redacted]. If you decide to withdraw from the study, all information about you will be destroyed.

Who can be in this study: You are eligible to participate in the study if: 1) you are between the age of 18 and 25 at the time you answer the questions; 2) you know either French or English well enough to

answer the questions; and 3) you have lived in your current residence for at least one year or more at the time you answer the questions.

Confidentiality: We assure you that all the information you give us will be treated in a strictly confidential manner. The principal investigator and the research coordinators are the only people who will have access to your data. All data will be kept in locked cabinets at the University of Montreal, or in password-protected electronic files, for a maximum of 7 years after the project is completed. The general results of the ISIS study, which will be published in journals and on the website (www.isis-montreal.ca), and presented at conferences, will make it impossible to identify any of the participants. As part of the monitoring of the research project, your file may be consulted by a person mandated by the Research Ethics Committee of the University of Montreal's Faculty of Medicine or by representatives of the Canadian Institutes of Health Research. All of these follow strict policies of confidentiality.

Benefits and inconveniences: Your answers to this questionnaire will help us to better understand the link between neighbourhoods and health among young adults. This will help us develop better strategies to improve the health and well-being of Montreal's population In addition, we will share with you the general results of the study by sending you newsletters over the course of the study. There is no inconvenience to you associated with taking part in the ISIS study, except for the time it takes you to answer the questionnaire.

Possible suspension from the study: The principal investigator can decide to suspend anyone's participation in the study if she believes it is in the participant's best interest, if the participant no longer meets the inclusion criteria, or for any other reason the principal investigator deems valid.

Contact persons: If you have any questions or concerns about your rights as a participant in this study, feel free to contact the Research Ethics Committee of the University of Montreal's Faculty of Medicine ([redacted]). If you have a complaint about this study, you can contact the University of Montreal's ombudsman at [redacted], or by email at [redacted]. The ombudsman accepts collect calls.

Consent: By signing this form, you confirm that you have read and understood its content. You understand that your participation is voluntary and that you are free to withdraw from the study at any time. Finally, you accept being contacted by members of the research team at any time, as needed, either for follow-up or to get your feedback.

We thank you in advance for your collaboration in this important project!

The ISIS team,

Katherine L. Frohlich
Principal Researcher

Rowena Agouri
Coordinator

ISIS
health and neighbourhoods

Please complete the section below and send the form back to us.
The duplicate copy is yours to keep.

☐ **I agree** to participate in the ISIS study

☐ **I do not agree** to participate in the ISIS study

Your name (in CAPITAL letters)	Your signature	Date

Consent form

ISIS – Health and Neighbourhoods

Principal Investigator:

Katherine L. Frohlich
[redacted]

Co-Investigators:

Thomas Abel, Michael Cantinotti, Mark Daniel, Clément Dassa, Geetanjali Datta, Yan Kestens, Bernard-Simon Leclerc, Jennifer O'Loughlin, Louise Potvin, Martine Shareck, Julie Vallée

Objective of the project: The aim of the *Interdisciplinary Study of Inequalities in Smoking* (ISIS) of the University of Montreal is to examine the link between young adult Montrealers' health and their neighbourhoods. We also want to understand why tobacco use remains high in low-income groups and what neighbourhood aspects most influence differences related to tobacco use. The ISIS cohort consists of 2093 young adult Montrealers.

How it works: Approximately two years ago, you completed the first ISIS questionnaire and thereby, you joined the ISIS cohort. As a member of this cohort, we will ask you to fill out a second questionnaire, similar to the first but with more questions, on different aspects of your life, such as the neighbourhood in which you live, your cigarette consumption, your work and your studies. This second questionnaire will allow us to better understand how your life has changed (or not) in the last two years. This questionnaire will take about 20 minutes to complete. You can choose to fill out the questionnaire by: 1) completing it online on a password-protected website; 2) filling out a paper version yourself; 3) filling it out over the phone with one of our team members or; 4) doing a face-to-face interview at the time and place of your choice. Once you have submitted your completed questionnaire, we will send you a $10 gift certificate redeemable at the retailer of your choice: iTunes, Renaud-Bray or Cineplex Odeon. Your continued participation is extremely important. For this reason, someone in charge of interviews might contact you at home, by phone or in person as part of this study at a future date.

Participation: Your participation in the ISIS study is entirely voluntary. You can choose to participate, to not participate, or to withdraw from the study at any point. If any of the questions make you feel uncomfortable, or if you feel they might cause you psychological harm, you can refuse to answer them. If you do not agree to participate, or decide to withdraw from the study, you do not need to justify your decision and there will be no negative consequences. You may withdraw from the study at any time by contacting the study's coordinator: Josée Lapalme, at [redacted] or by email at [redacted]

Who can be in this study: As a ISIS cohort member, you are eligible to participate in the study if you live in Montreal's metropolitan area while completing the questionnaire.

Confidentiality: We assure you that all the information you give us will be treated in a strictly confidential manner. The principal investigator and the research coordinators are the only people who

will have access to your data. All data will be kept in locked cabinets at the University of Montreal, or in password-protected electronic files, for a maximum of 7 years after the project is completed. The general results of the ISIS study, which will be published in journals and on the website (www.isis- montreal.ca), and presented at conferences, will make it impossible to identify any of the participants. As part of the monitoring of the research project, your file may be consulted by a person mandated by the Comité d'éthique de la recherche en santé (CERES) de l'Université de Montréal or by representatives of the Canadian Institutes of Health Research. All of these follow strict policies of confidentiality.

Benefits and inconveniences: Your answers to this questionnaire will help us to better understand the link between neighbourhoods and health among young adults. This will help us develop better strategies to improve the health and well-being of Montreal's population In addition, we will share with you the general results of the study by sending you newsletters over the course of the study. There is no inconvenience to you associated with taking part in ISIS, except for the time it takes you to answer the questionnaire.

Possible suspension from the study: The principal investigator can decide to suspend anyone's participation in the study if she believes it is in the participant's best interest, if the participant no longer meets the inclusion criteria, or for any other reason the principal investigator deems valid.

Contact persons: If you have any questions or concerns about your rights as a participant in this study, feel free to contact the Comité d'éthique de la recherche en santé (CERES) de l'Université de Montréal . If you have a complaint about this study, you can contact the University of Montreal's ombudsman at , or by email at ombudsman@umontreal.ca. The ombudsman accepts collect calls.
[redacted]
For all other questions, please communicate with the project coordinator Josée Lapalme or with the principal investigator Katherine [redacted].

Consent: By giving your consent, you confirm that you have read and understood its content. You understand that your participation is voluntary and that you are free to withdraw from the study at any time. Finally, you accept being contacted by members of the research team at any time, as needed, either for follow-up or to get your feedback.

We thank you in advance for your collaboration in this important project!

The ISIS team,

Katherine L. Frohlich
Principal Researcher

Josée Lapalme
Coordinator

Please complete the section below and send the form back to us.
The duplicate copy is yours to keep.

☐ **I agree** to participate in the ISIS study

☐ **I do not agree** to participate in the ISIS study

Your name (in CAPITAL letters)	**Your signature**	**Date**

APPENDIX II: Ethical Approval

Université de Montréal

N° de certificat
15-055-CERES-D

Comité d'éthique de la recherche en santé

CERTIFICAT D'APPROBATION ÉTHIQUE

Le Comité d'éthique de la recherche en santé (CERES), selon les procédures en vigueur, en vertu des documents qui lui ont été fournis, a examiné le projet de recherche suivant et conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal.*

Projet	
Titre du projet	**Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space**
Étudiant requérant	**Adrian Esteban Ghenadenik** ([redacted] Candidat au Ph. D. en santé publique (option promotion de la santé), École de santé publique - Département de médecine sociale et préventive
Sous la direction de	Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive, Université de Montréal & Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive, Université de Montréal.

Financement	
Organisme	IRSC
Programme	Subvention de fonctionnement
Titre de l'octroi si différent	Interdisciplinary Study of Inequalities in Smoking (ISIS)
Numéro d'octroi	231010
Chercheur principal	Katherine Frohlich
No de compte	N.D.

MODALITÉS D'APPLICATION

Tout changement anticipé au protocole de recherche doit être communiqué au CERES qui en évaluera l'impact au chapitre de l'éthique.

Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CERES

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CERES.

[redacted]

Dominique Langelier, présidente
Comité d'éthique de la recherche en santé
Université de Montréal

23 avril 2015
Date de délivrance

1er juillet 2017
Date de fin de validité

[redacted]

Université de Montréal

Comité d'éthique de la recherche en santé

19 mai 2016

Objet: Certificat d'approbation éthique - 1er renouvellement – « Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space »

M. Adrian Esteban Ghenadenik,

Le Comité d'éthique de la recherche en santé (CERES) a étudié votre demande de renouvellement pour le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences qui prévalent. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

Notez qu'il y apparaît une mention relative à un suivi annuel et que le certificat comporte une date de fin de validité. En effet, afin de répondre aux exigences éthiques en vigueur au Canada et à l'Université de Montréal, nous devons exercer un suivi annuel auprès des chercheurs et étudiants-chercheurs.

De manière à rendre ce processus le plus simple possible et afin d'en tirer pour tous le plus grand profit, nous avons élaboré un court questionnaire qui vous permettra à la fois de satisfaire aux exigences du suivi et de nous faire part de vos commentaires et de vos besoins en matière d'éthique en cours de recherche. Ce questionnaire de suivi devra être rempli annuellement jusqu'à la fin du projet et pourra nous être retourné par courriel. La validité de l'approbation éthique est conditionnelle à ce suivi. Sur réception du dernier rapport de suivi en fin de projet, votre dossier sera clos.

Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au CERES tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Monsieur, l'expression de nos sentiments les meilleurs,

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé (CERES)
Université de Montréal

c.c. Gestion des certificats, BRDV
Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive
Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive
TGDE - PhD Santé publique
p.j. Certificat #15-055-CERES-D

[redacted]

Université de Montréal

Comité d'éthique de la recherche en santé

N° de certificat
15-055-CERES-D(1)

CERTIFICAT D'APPROBATION ÉTHIQUE

- 1er renouvellement -

Le Comité d'éthique de la recherche en santé (CERES), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space**
Étudiant requérant	**Adrian Esteban Ghenadenik** [redacted], Candidat au Ph. D. en santé publique (option promotion de la santé), École de santé publique - Département de médecine sociale et préventive
Sous la direction de	Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive, Université de Montréal & Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive, Université de Montréal.

Financement	
Organisme	IRSC
Programme	Subvention de fonctionnement
Titre de l'octroi si différent	Interdisciplinary Study of Inequalities in Smoking (ISIS)
Numéro d'octroi	231010
Chercheur principal	Katherine Frohlich
No de compte	N.D.

MODALITÉS D'APPLICATION

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[redacted]

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé
Université de Montréal

19 mai 2016
Date de délivrance du renouvellement ou de la réémission*

1er juin 2017
Date du prochain suivi

23 avril 2015
Date du certificat initial

1er juin 2017
Date de fin de validité

*Le présent renouvellement est en continuité avec le précédent certificat

[redacted]

Université de Montréal

Comité d'éthique de la recherche en santé

17 octobre 2017

Objet: Certificat d'approbation éthique - 2ième renouvellement – « Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space »

M. Adrian Esteban Ghenadenik,

Le Comité d'éthique de la recherche en santé (CERES) a étudié votre demande de renouvellement pour le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences qui prévalent. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

Notez qu'il y apparaît une mention relative à un suivi annuel et que le certificat comporte une date de fin de validité. En effet, afin de répondre aux exigences éthiques en vigueur au Canada et à l'Université de Montréal, nous devons exercer un suivi annuel auprès des chercheurs et étudiants-chercheurs.

De manière à rendre ce processus le plus simple possible et afin d'en tirer pour tous le plus grand profit, nous avons élaboré un court questionnaire qui vous permettra à la fois de satisfaire aux exigences du suivi et de nous faire part de vos commentaires et de vos besoins en matière d'éthique en cours de recherche. Ce questionnaire de suivi devra être rempli annuellement jusqu'à la fin du projet et pourra nous être retourné par courriel. La validité de l'approbation éthique est conditionnelle à ce suivi. Sur réception du dernier rapport de suivi en fin de projet, votre dossier sera clos.

Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au CERES tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Monsieur, l'expression de nos sentiments les meilleurs,

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé (CERES)
Université de Montréal

c.c. Gestion des certificats, BRDV
Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive
Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive
TGDE - PhD Santé publique
p.j. Certificat #15-055-CERES-D(2)

[redacted]

Université de Montréal

Comité d'éthique de la recherche en santé

N° de certificat
15-055-CERES-D(2)

CERTIFICAT D'APPROBATION ÉTHIQUE

- 2ième renouvellement -

Le Comité d'éthique de la recherche en santé (CERES), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space**
Étudiant requérant	**Adrian Esteban Ghenadenik** ([redacted], Candidat au Ph. D. en santé publique (option promotion de la santé), École de santé publique - Département de médecine sociale et préventive
Sous la direction de	Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive, Université de Montréal & Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive, Université de Montréal.

Financement	
Organisme	IRSC
Programme	Subvention de fonctionnement
Titre de l'octroi si différent	Interdisciplinary Study of Inequalities in Smoking (ISIS)
Numéro d'octroi	231010
Chercheur principal	Katherine Frohlich
No de compte	N.D.

MODALITÉS D'APPLICATION

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[redacted]

Guillaume Paré
Conseiller en éthique de la recherche.
Comité d'éthique de la recherche en santé
Université de Montréal

17 octobre 2017
Date de délivrance du renouvellement ou de la réémission*

1er novembre 2018
Date du prochain suivi

23 avril 2015
Date du certificat initial

1er novembre 2018
Date de fin de validité

*Le présent renouvellement est en continuité avec le précédent certificat

[redacted]

Université de Montréal

Comité d'éthique de la recherche en sciences et en santé (CERSES)

13 novembre 2018

Objet: Certificat d'approbation éthique - 3ième renouvellement – « Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space »

M. Adrian Esteban Ghenadenik,

Le Comité d'éthique de la recherche en sciences et en santé (CERSES) a étudié votre demande de renouvellement pour le projet de recherche susmentionné et a délivré le certificat d'éthique demandé suite à la satisfaction des exigences qui prévalent. Vous trouverez ci-joint une copie numérisée de votre certificat; copie également envoyée à votre directeur/directrice de recherche et à la technicienne en gestion de dossiers étudiants (TGDE) de votre département.

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Il est entendu que cela ne modifie en rien l'obligation pour le chercheur, tel qu'indiqué sur le certificat d'éthique, de signaler au Comité tout incident grave dès qu'il survient ou de lui faire part de tout changement anticipé au protocole de recherche.

Nous vous prions d'agréer, Monsieur, l'expression de nos sentiments les meilleurs,

Guillaume Paré
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Comité d'éthique de la recherche en sciences et en santé (CERSES)
Université de Montréal

c.c. Gestion des certificats, BRDV
Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive
Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive
TGDE - PhD Santé publique
p.j. Certificat #15-055-CERES-D(3)

[redacted]

Université de Montréal

Comité d'éthique de la recherche en sciences et en santé (CERSES)

N° de certificat
15-055-CERES-D(3)

CERTIFICAT D'APPROBATION ÉTHIQUE

- 3ième renouvellement -

Le Comité d'éthique de la recherche en sciences et en santé (CERSES), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Neighbourhoods and smoking in young adults: Understanding the role of geographic scale in time and space**
Étudiant requérant	**Adrian Esteban Ghenadenik** [redacted], Candidat au Ph. D. en santé publique (option promotion de la santé), École de santé publique - Département de médecine sociale et préventive
Sous la direction de	Katherine Leigh Frohlich, professeure agrégée, École de santé publique - Département de médecine sociale et préventive, Université de Montréal & Lise Gauvin, professeure titulaire, École de santé publique - Département de médecine sociale et préventive, Université de Montréal.

Financement	
Organisme	IRSC
Programme	Subvention de fonctionnement
Titre de l'octroi si différent	Interdisciplinary Study of Inequalities in Smoking (ISIS)
Numéro d'octroi	231010
Chercheur principal	Katherine Frohlich
No de compte	N.D.

MODALITÉS D'APPLICATION

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[redacted]

Guillaume Paré
Conseillère en éthique de la recherche
Comité d'éthique de la recherche en sciences et en santé (CERSES)
Université de Montréal

13 novembre 2018
Date de délivrance du renouvellement ou de la réémission*

1er décembre 2019
Date du prochain suivi

23 avril 2015
Date du certificat initial

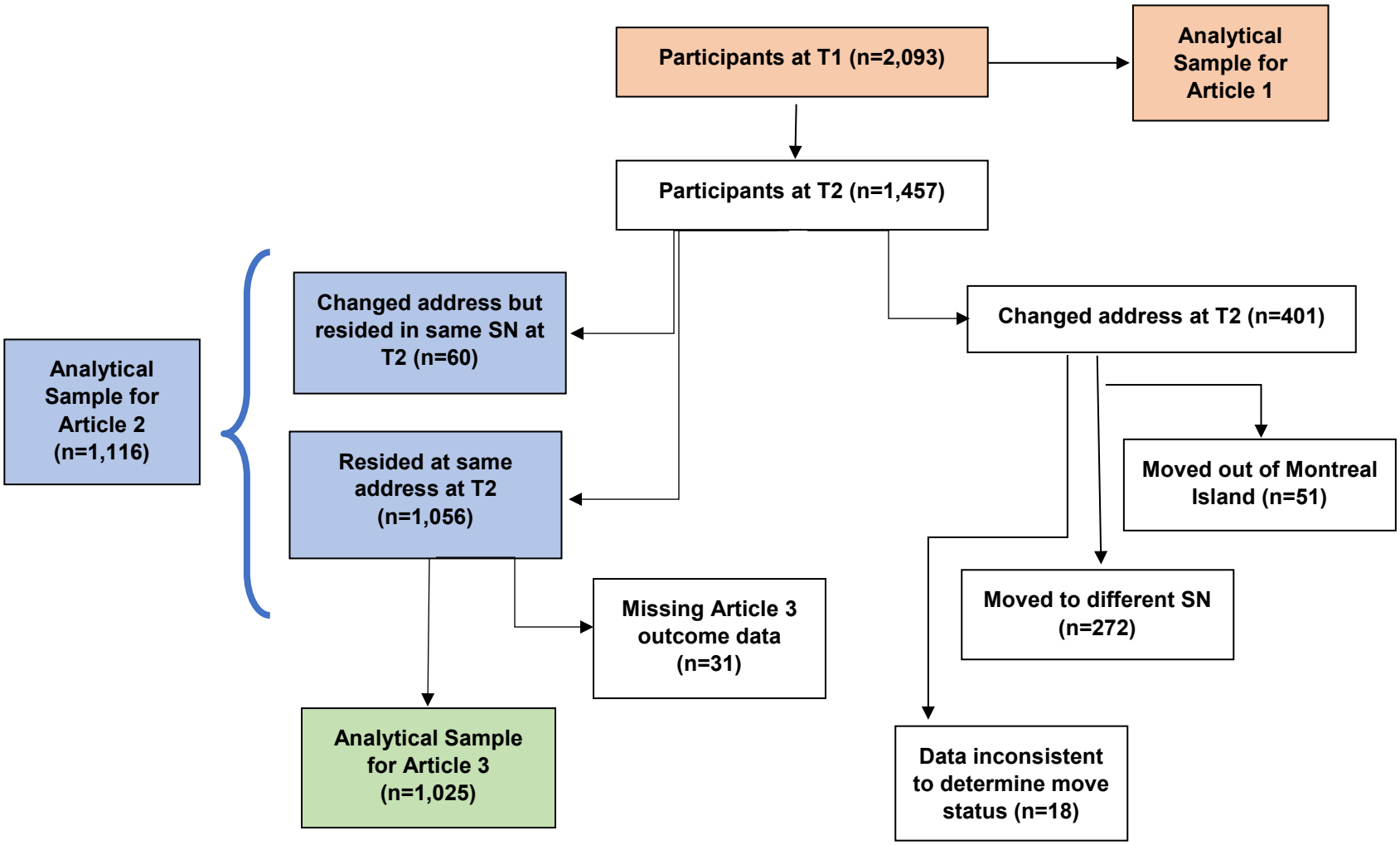
1er décembre 2019
Date de fin de validité

*Le présent renouvellement est en continuité avec le précédent certificat

[redacted]

APPENDIX III: Diagram detailing the number of participants by time of survey and reasons for inclusion/exclusion from dissertation analytical samples

Appendix III: Diagram detailing the number of participants by time of survey and reasons for inclusion/exclusion from dissertation analytical samples



APPENDIX IV: ISIS Neighbourhood Observation Grid

Grille d'observation ISIS 2012					
Indicateur	**Choix de réponse**				
Configuration routière					
15. Présence de ruelle	Oui	Non			
16. Configuration	Linéaire	Croissant	Cul-de-sac		
17. Nombre de voies	1	2	3	4+	NSP
Sécurité					
Dispositifs de sécurité					
18.1 Dos d'âne	Oui	Non			
18.2 Obstacle, rétrécissement, barrière	Oui	Non			
18.3 Feu circulation pour voitures	Oui	Non			
18.4 Feu pour piétons	Oui	Non			
18.5 Signes d'arrêt/stop	Oui	Non			
18.6 Traverse piétonnière	Oui	Non			
Esthétique					
19. Petits arbres	0	1 - 5	6 - 10	11 +	
20. Grands arbres	0	1 - 5	6 - 10	11 +	
21. Plantes/fleurs/déco/arbustes public	0	- 1/4	1/4 - 1/2	+ 1/2	
22. Fleurs/déco/arbustes privé	Auc. rés./comm.	0	- 1/4	1/4 - 1/2	+ 1/2
Propreté					
23. Objets abandonnés					
23.1 Véhicules	Oui	Non			
23.2 Bicyclettes	Oui	Non			
23.3 Électroménagers, meubles	Oui	Non			
23.4 Pneus	Oui	Non			
23.5 Matériaux construction	Oui	Non			
24. Mégôts	0 - 10	11 - 50	51 +		
25. Paquets/emballages cigarettes	#:				
26. Déchet/verre brisé/excréments	Aucun	< feuille	feuille - sac carton	> sac carton	
27. Poubelles: nbre total	#:				
Sociabilité locale					
28. Affiches lisibles	0	1 - 3	4 - 10	11 +	

Accommodements fumeurs					
29. Terrasses	#:				
Désordre					
30. Graffitis/tags (aires: carton affichage)	0	1 - 2	3 - 6	7 +	
Revitalisation					
31. Murales	0	1	2 - 3	4 +	
Commerces					
32. Condition globale	Aucun comm.	Mauvaise	Bonne	Excellente	
33. Cendriers à proximité	Aucun comm.	0	- 1/4	1/4 - 1/2	+ 1/2
34. À vendre ou à louer	Aucun comm.	# à vendre/louer:			
35. Fermé sans indication	Aucun comm.	# fermés sans indication:			
36. Vendant produits tabac	Aucun comm.	# vendant produits du tabac:			
37. Quels produits étaient-vendus?	**Cigarettes**	**Cigares**	**Cigarillos**	**Autre**	
37.1 Commerce 1	Oui	Oui	Oui	Oui	
37.2 Commerce 2	Oui	Oui	Oui	Oui	
37.3 Commerce 3	Oui	Oui	Oui	Oui	
37.4 Commerce 4	Oui	Oui	Oui	Oui	
Résidences					
38. Condition globale	Aucune rés.	Mauvaise	Bonne	Excellente	
39. En rénovation	Aucune rés.	# en réno.:		Note:	
40. À vendre	Aucune rés.	# à vendre:			
Institutions					
41. Nombre d'institutions	# inst.:				
42. Condition globale	Aucune inst.	Mauvaise	Bonne	Excellente	
43. Plantes/fleurs/décos/arbustes instit.	Oui	Non			
44. Cendriers à proximité	# inst. avec cendrier:				
45. Loi anti-tabac affichée	# inst. affichant loi anti-tabac:				
46. Loi anti-tabac respectée?	# fumeurs à <9m entrée publique:				
Organisations communautaires					
47. Nombre d'org. comm.	# org. comm.:				
48. Condition globale	Aucune org.	Mauvaise	Bonne	Excellente	
49. Cendriers à proximité	# org. comm. avec cendrier:				

Qualité environnement physique						
50. Ressources/installations	**a. Présence**		**b. Condition**			
50.1 Espace vert public	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.2 Sentier pédestre/Piste course	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.3 Piste cyclable	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.4 Aire jeu, table, grill, modules	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.5 Bancs dans un parc	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.6 Bancs sur le trottoir	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.7 Bord de l'eau	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.8 Terrain de soccer	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.9 Terrain de basketball	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.10 Terrain de baseball	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.11 Terrain de tennis	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.12 Piscine/Pataugeoire	Oui	Non	Mauvaise	Bonne	Excellente	Impossible
50.13 Autre, décrire:	Oui	Non	Mauvaise	Bonne	Excellente	Impossible

APPENDIX V: ISIS Individual Questionnaire T1

Questionnaire on the health and neighbourhoods of young adult Montrealers

Thank you very much for your interest in the ISIS Project! Your participation is very important to us.

In the following pages we will ask you questions about different aspects of your life. We would like some information from you so that we can better understand the link between neighbourhoods and health among young adult Montrealers. More specifically, the questions are about:

- Your neighbourhood
- Your health
- Your cigarette use
- Your life and your social network
- Your cultural background and religious beliefs
- Your work and your studies
- Your housing
- Your expenses
- Places where you spend time

We pledge to never publish any personal information that would make it possible to identify you. If there is any question you would rather not answer, please just go on to the next one.

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

- Most of the questions are multiple choice. Select the answer that applies to you by filling in the appropriate circle.
- Choose only one answer for each question, unless the instructions say otherwise.
- When you have finished, please mail us the questionnaire and the signed consent form in the envelope provided.

If you have any questions, please don't hesitate to contact us:
☎

QUESTIONS ABOUT ELIGIBILITY

A1. Are you between 18 and 25 years of age?

O Yes
O No → **We're sorry, but you cannot take part in the study. Thank you for your time.**

A2. What is your birth date?

_____ _____ _____
DAY MONTH YEAR

A3. What is your current address?

NUMBER AND STREET NAME:

_____

CITY:

_____

PROVINCE:

_____

POSTAL CODE:

_____

A4. How long have you been living at your current address?

O Less than 1 year → **We're sorry, but you cannot take part in the study. Thank you for your time.**
O 1 year or more → **Go to question 1**

YOUR NEIGHBOURHOOD

1. When thinking about your neighbourhood, what comes to mind?

O The street or the block where your home is located
O A few streets or blocks around your home
O The area covered by a 15-minute walk from your home
O An area covered by a walk that is more than 15 minutes from your home

2. In your neighbourhood, how many people can you say hello to on a regular basis?

O No one
O A few people
O Several people
O Most people

Please indicate how much you agree or disagree with the following three statements:

3. I can trust the people in my neighbourhood.

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

4. I feel safe going out alone at night in my neighbourhood.

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

5. The people in my neighbourhood help each other out (for example, lending tools, picking up mail, letting others use their telephone, etc.).

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

YOUR HEALTH

6. Compared to other people your age, would you say that, in general, your physical health is:

O Excellent
O Very good
O Pretty good
O Fair
O Poor
O I don't know

7. Compared to other people your age, would you say that, in general, your mental health is:

O Excellent
O Very good
O Pretty good
O Fair
O Poor
O I don't know

8. When you have questions about your health, who do you ask first? Choose all the answers that apply to you.

O A health professional (for example, a doctor, pharmacist, or nurse)
O A member of your family
O A friend or another person (for example, a co-worker, a neighbour, or someone else you know)
O You look for answers on the Internet
O You don't ask anyone

9. When you were a child, how much importance did your parents attribute to a healthy lifestyle?

O No importance
O Little importance
O Some importance
O A lot of importance
O I don't know

10. Are you able to…
[Please check one answer per line]

	Completely able	Somewhat able	Not very able	Not at all able	I don't know
Carry an 8-kg (18 lbs) weight up 3 flights of stairs (for example, 6 full bags of groceries)	O	O	O	O	O
Raise your upper body from a lying position without using your arms (sit-up)	O	O	O	O	O
Carry 2 heavy suitcases up 3 flights of stairs	O	O	O	O	O
Walk 20 minutes (about 2 kilometres or 1 mile) at a sustained pace without a break	O	O	O	O	O
Run 6 minutes (about 1 kilometre or ½ mile) without a break	O	O	O	O	O
Run 30 minutes (about 5 kilometres or 3 miles) without a break	O	O	O	O	O
Touch the floor with your hands while sitting in a chair	O	O	O	O	O
Touch the floor with your hands while standing (without bending your knees)	O	O	O	O	O
Touch your knees with your head while standing	O	O	O	O	O

	Completely able	Somewhat able	Not very able	Not at all able	I don't know
Stay balanced on one leg (at least 15 seconds) without holding on to anything	O	O	O	O	O
Do a somersault	O	O	O	O	O
Jump over a 1-meter (3-foot) high fence by supporting yourself on it	O	O	O	O	O

11. Do you suffer from one of the following health problems: chronic bronchitis, persistent cough or asthma?

O Yes
O No
O I don't know

YOUR CIGARETTE USE

12. In your life, have you smoked a total of 100 cigarettes or more (around 4 packs)?

O Yes → **go to question 14**
O No

13. Have you ever smoked an entire cigarette?

O Yes
O No → **go to question 29**

14. How old were you when you smoked an entire cigarette for the first time?

_____years

15. Currently, do you smoke cigarettes every day, sometimes or never?

O Every day
O Sometimes → **go to question 20**
O Never → **go to question 26**

If you smoke every day

16. How old were you when you started smoking cigarettes every day?

_____years

17. Currently, how many cigarettes do you smoke each day?

_____cigarette(s) per day

18. How do you get your tobacco products (cigarettes, rolling tobacco, cigarillos)? Choose <u>all</u> the answers that apply to you.

O At the convenience store (dépanneur) or the tobacco store
O At the grocery store
O From friends, co-workers or other people you know
O From members of your family
O On an Indian reserve
O Other, specify: _____

19. In what form do you get cigarettes? Choose <u>all</u> the answers that apply to you.

O As singles → **go to question 29**
O By the pack → **go to question 29**
O As a carton → **go to question 29**
O In a plastic bag (Ziploc®-type) → **go to question 29**
O As rolling tobacco → **go to question 29**
O Other, specify:_____→ **go to question 29**

If you smoke sometimes

20. On the days when you smoke, how many cigarettes do you usually smoke?

_____cigarette(s) per day

21. In the past month, how many days did you smoke one cigarette or more?

_____ day(s)

22. How do you get your tobacco products (cigarettes, rolling tobacco, cigarillos)? Choose <u>all</u> the answers that apply to you.

O At the convenience store (dépanneur) or the tobacco store
O At the grocery store
O From friends, co-workers or other people you know
O From members of your family
O On an Indian reserve
O Other, specify: _____

23. In what form do you get cigarettes? Choose <u>all</u> the answers that apply to you.

O As singles
O By the pack
O As a carton
O In a plastic bag (Ziploc®-type)
O As rolling tobacco
O Other, specify: _____

24. Have you ever smoked cigarettes every day?

O Yes
O No → **go to question 29**

25. When did you stop smoking every day?

O Less than 1 year ago → **go to question 29**
O From 1 year ago to less than 2 years ago → **go to question 29**
O From 2 years ago to less than 3 years ago → **go to question 29**
O 3 or more years ago → **go to question 29**

If you never smoke

26. Have you ever smoked cigarettes every day?

O Yes
O No → **go to question 28**

27. When did you stop smoking every day?

O Less than 1 year ago → **go to question 29**
O From 1 year ago to less than 2 years ago → **go to question 29**
O From 2 years ago to less than 3 years ago → **go to question 29**
O 3 or more years ago → **go to question 29**

28. When was the last time you smoked a cigarette?

O Less than 1 year ago
O From 1 year ago to less than 2 years ago
O From 2 years ago to less than 3 years ago
O 3 or more years ago

29. How many of your friends smoke?

O None
O One or a few
O About half
O Most
O All
O I don't know

30. How many members of your immediate family smoke?

O None
O One or a few
O About half
O Most
O All
O I don't know

YOUR LIFE AND YOUR SOCIAL NETWORK

31. What is your marital status?

O Single
O Married
O Common-law or in a couple
O Separated or divorced
O Widowed

32. In general, how satisfied are you with your relationships with your friends?

O Very satisfied
O Somewhat satisfied
O Somewhat dissatisfied
O Very dissatisfied

33. Is there anyone in your social circle (your friends or family, or other people you trust) that you can confide in and talk openly with about your problems?

O Yes
O No → **go to question 35**
O I don't know → **go to question 35**

34. How many people?

O 1
O 2
O 3
O 4
O 5 ormore

35. Is there anyone in your social circle (your friends or family) who can help you if you have a problem?

O Yes
O No → **go to question 37**
O I don't know → **go to question 37**

36. How many people?

O 1
O 2
O 3
O 4
O 5 ormore

37. Is there anyone in your social circle (friends or family) that you feel close to and is affectionate toward you?

O Yes
O No → **go to question 39**
O I don't know → **go to question 39**

38. How many people?

O 1
O 2
O 3
O 4
O 5 ormore

YOUR CULTURAL BACKGROUND AND RELIGIOUS BELIEFS

39. Were you born in Canada?

O Yes → **go to question 42**
O No

40. In what country were you born?

Name of country: _____

41. How old were you when you immigrated to Canada?

_____year(s)

42. In what country/countries were your parents born?

Mother: _____

Father: _____

43. What language(s) do you speak most often at home? Choose all the answers that apply to you.

O French
O English
O Other, specify: _____

44. Do you identify with any religion?

O Yes
O No → **go to question 47**

45. How important is your religion to you?

O Not at all important
O Not very important
O Somewhat important
O Very important

46. In the past 12 months, how often did you attend or participate in religious activities, services or meetings, aside from weddings or funerals?

O At least once a week
O At least once a month
O At least 3 times a year
O Once or twice a year
O Never

YOUR WORK AND YOUR STUDIES

47. If needed, can anyone in your family put you in contact with people who can help you improve your employment situation?

O Most probably
O Probably
O Not very probably
O Not at all probably
O Does not apply (no contact, deceased, etc.)
O I don't know

48. Please estimate how many books were in your home when you were a child. Were there…

O Fewer than 10 books
O Between 10 and 49 books
O Between 50 and 199 books
O Between 200 and 399 books
O 400 books or more
O I don't know

49. What is the highest level of education you have <u>completed</u>?

O No school, or only kindergarten
O Elementary school
O Secondary 4 or less (10th grade or less)
O Secondary 5 (11th grade)
O Diploma or certificate of studies in a technical program at a CEGEP, a trade school, a commercial or private college, a technical institute, or a nursing school
O Diploma or certificate of studies in a general program at a CEGEP
O University undergraduate certificate
O Bachelor's degree
O Degree in medicine, dentistry, veterinary medicine, optometry or chiropracty
O University graduate certificate
O Master's degree
O Earned doctorate

YOUR HOUSING

50. Including yourself, how many people currently live or reside at your address?

O 1 → **go to question 52**
O 2
O 3
O 4
O 5
O 6
O 7
O 8
O 9
O 10 ormore

51. Who do you currently live with? Choose all the answers that apply to you.

I live…

O With both my parents
O With one of my parents
O With my brothers and sisters
O With grandparents or other members of my family
O With my partner/spouse
O With my children or my partner/spouse's children
O With roommates, friends or other people I know
O Other

52. Who owns the home you live in?

I am / a member of my family is the …

O Owner of the home
O Tenant in the home

53. How many rooms are there in the home you live in?
Please include all the rooms except the bathroom and hallway(s).

O 1
O 2
O 3
O 4
O 5
O 6
O 7
O 8
O 9 ormore

YOUR EXPENSES

54. With the following questions we want to find out whether, in the past 12 months, you ever didn't have enough money to pay for various things needed for daily life. If this has happened to you, we would like to know how serious that situation was.

[On each line, please check one answer in the first section; if your answer is "yes", please also check one box in the second section]

	In the past 12 months, did you, or the person responsible for this expense, ever not have enough money to…			If yes, how serious was this lack of money?				
	Yes	No	I don't know	Not at all serious	A little serious	Somewhat serious	Very serious	I don't know
… pay the rent or mortgage?	O	O	O	O	O	O	O	O
… pay for electricity, hot water, or heat?	O	O	O	O	O	O	O	O
… buy food?	O	O	O	O	O	O	O	O

55. If you needed money urgently, could you borrow $500 quickly from the following persons?

[Please check one answer on each line]

	Yes	No	Does not apply (no contact, deceased, etc.)	I don't know
Your mother	O	O	O	O
Your father	O	O	O	O
Your partner/spouse	O	O	O	O
A brother or sister	O	O	O	O
A grandparent	O	O	O	O
A friend	O	O	O	O
A co-worker	O	O	O	O
Other	O	O	O	O

PLACES WHERE YOU SPEND TIME

Your neighbourhood and the places where you spend time might affect your health. The following questions are about the places where you spend time on a regular basis. For each category, please identify as precisely as possible the place where you do the activity in question, giving the exact address if you know it or the intersection and/or a landmark closest to the place, as well as the neighbourhood and the city. For some types of activities, you can indicate two places, starting with the one you go to most often.

Studies

56. Are you currently a student (either full-time, part-time, or in an internship program)?

O Yes
O No → **go to question 60**

57. What is the name of the institution you attend for your studies, including the campus and the building (if these apply)?

NAME OF THE INSTITUTION:
_____

NAME OF THE CAMPUS :
_____

NAME OF THE BUILDING :
_____

58. What is the address of this study location? If you are studying at home or doing a distance learning program, please indicate it here.

NUMBER AND/OR STREET NAME:
_____

INTERSECTION :
_____ AND _____

CLOSEST LANDMARK :
_____

NEIGHBOURHOOD : CITY:
_____ _____

59. In a typical 7-day week, how many hours do you spend at this place for school purposes?

_____hour(s) per week

Work

60. Are you currently in paid employment?

This includes full-time work or part-time work, whether you are an employee, self-employed, a freelancer, on contract, in an internship, on vacation, on parental leave, on sick leave or work-accident leave, on strike or lock-out situation.

O Yes
O No → **go to question 71**

61. If you are currently in paid employment, do you work… Choose all the answers that apply to you.

O Full-time
O Part-time
O On contract or freelance

62. Where do you work? You can name up to two jobs or workplaces, if necessary.

Job or workplace 1

NAME OF COMPANY OR EMPLOYER:

_____

63. Usually, do you work mostly :

O from home → **go to question 65**
O on the road → **go to question 66**
O neither at home nor on the road

64. What is the address of this workplace?

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

POSTAL CODE :

_____

NEIGHBOURHOOD : CITY:

_____ _____

65. In a typical 7-day week, how many hours do you spend at this place for work purposes?

_____hour(s) per week

66. Do you work anywhere else, either as part of this job, or for another job?

O Yes, I have another job
O Yes, I work somewhere else as part of this same job → **go to question 68**
O No, I always work in the same place → **go to question 71**

Job or workplace 2

67. Where do you work mostly?

NAME OF COMPANY OR EMPLOYER:

_____

68. Usually, do you work :

O from home → **go to question 70**
O on the road → **go to question 71**
O neither at home nor on the road

69. What is the address of this second workplace?

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

POSTAL CODE :

_____

NEIGHBOURHOOD : CITY:

_____ _____

70. In a typical 7-day week, how many hours do you spend at this place for work purposes?

_____hour(s) per week

Grocery shopping

71. In your household, who does the grocery shopping?

O Only you
O Partly you
O Someone other than you → **go to question 77**

72. When you are the one doing the grocery shopping, where do you go? You can name up to two places (if necessary), starting with the place you go to most often.

Primary place:

NAME OF THE PLACE (example: “Such-and-such” grocery store, “Such-and-such” convenience store, “Such-and-such” public market) :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

73. In the past month, how many times have you gone to this place to buy groceries?

_____time(s) in the past month

74. Is there another place where you regularly do your grocery shopping?

O Yes

O No → **go to question 77**

Second place

75. What are the name and the address of this second place where you do your grocery shopping?

NAME OF THE PLACE (example: “Such-and-such” grocery store, “Such-and-such” convenience store, “Such-and-such” public market) :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

76. In the past month, how many times have you gone to this place to buy groceries?

_____time(s) in the past month

Physical activities and sports

77. Do you regularly engage in physical activity or sports?

O Yes
O No → **go to question 81**

78. Do you usually engage in physical activity or sports in a particular place?

O Yes, I usually do these types of activities at home → **go to question 80**
O Yes, I usually do these types of activities other than at home, in one specific place that I go to regularly
O No, I do not do these types of activities at one specific place on a regular basis → **go to question 81**

79. Where do you usually engage in physical activity or sports?

NAME OF THE PLACE :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

80. In a typical 7-day week, how many hours do you spend at this place doing physical activity or sports?

_____hour(s) per week

Leisure activities

81. Do you regularly engage in leisure activities?

O Yes
O No → **go to question 85**

82. Do you usually engage in leisure activities in a particular place?

O Yes, I usually do these types of activities at home → **go to question 84**
O Yes, I usually do these types of activities other than at home, in one specific place that I go to regularly
O No, I do not do these types of activities at one specific place on a regular basis → **go to question 85**

83. Where do you usually engage in leisure activities?

NAME OF THE PLACE :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

84. In a typical 7-day week, how many hours do you spend at this place doing leisure activities?

_____hour(s) per week

Other places where you spend time

85. Aside from the places you've already mentioned, are there other places where you regularly spend time?

These could be public places or private homes (yours or someone else's). They could be places where you spend time with friends, your partner/spouse or members of your family, or where you engage in sports or leisure, or where you are doing a study or professional internship, volunteering, or engaging in social or religious activities.

O Yes
O No → **go to question 93**

86. What are the name and address of this place where you regularly spend time? You will be able to name up to two places (if necessary), starting with the one where you spend the most time.

NAME OF THE PLACE :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

87. In a typical 7-day week, how many hours do you spend at this place?

_____hour(s) per week

88. What do you usually do there?

_____

89. Is there another place where you regularly spend time?

O Yes
O No → **go to question 93**

90. What are the name and address of this other place where you regularly spend time?

NAME OF THE PLACE :

_____

NUMBER AND/OR STREET NAME:

_____

INTERSECTION :

_____ AND _____

CLOSEST LANDMARK :

_____

NEIGHBOURHOOD : CITY:

_____ _____

91. In a typical 7-day week, how many hours do you spend at this place?

_____hour(s) per week

92. What do you usually do there?

_____

The following three questions are about your access to different means of transportation.

93. Do you have a driver's license?

O Yes
O No

94. Do you own a car, or have a car at your disposal (for example, the car of a friend or family member, or membership in a car sharing system such as *Communauto*, etc.)?

O Yes
O No

95. Do you have a monthly public transit pass (bus, metro and/or train)?

O Yes
O No

A FEW LAST QUESTIONS

Even though healthcare expenses are partly covered by Quebec's public health insurance program, there continues to be a link between health status and income. We would appreciate it if you could answer the three following questions so that we can study this link. Please be assured that all the information collected as part of this study will be treated strictly confidentially.

96. Approximately what was your total personal income LAST YEAR, before tax deductions? Please include any financial aid you may have received (for example, a scholarship, employment insurance benefits, CSST or other insurance benefits, etc.)

O No personal income
O $1 to $4,999
O $5,000 to $9,999
O $10,000 to $14,999
O $15,000 to $19,999
O $20,000 to $29,999
O $30,000 to $39,999
O $40,000 to $49,999
O $50,000 to $99,999
O $100,000 and more
O I don't know

97. Do you have any financial investments (for example, savings bonds, RRSPs, TFSAs, certificates of deposit, stocks, etc.)?

O Yes
O No

98. In the past 12 months, have you received any social assistance, that is, financial aid provided as a last resort (also known as welfare assistance)?

O Yes
O No

END OF THE QUESTIONNAIRE

SELECT YOUR GIFT CERTIFICATE

As a way to thank you for completing this questionnaire, the ISIS team will give you a $10 gift certificate redeemable at one of the following retailers. Please choose the retailer for which you would like a gift certificate (only one selection per participant).

O iTunes
O Renaud-Bray
O Cineplex Odeon

YOUR CONTACT INFORMATION

We might contact you again within the next two years to find out whether your address has changed before sending you the new questionnaire. We might also email you to share the results of the study. We will contact you a maximum of three times per year, and you can choose at any time to stop these contacts. We would therefore appreciate it very much if you would give us your email address and telephone number, as well as the contact information of a person close to you, so that we can make sure to reach you for the next phase of the study. This person will only be contacted if we are having trouble reaching you.

Your email address: _____

Your telephone number: _____

The name of a person close to you who we can contact if we are having trouble reaching you:

_____

Your relationship with this person: _____

This person's email address: _____

This person's telephone number: _____

☐ I will inform this person about this study and the reasons why I gave his/her contact information

COMMENTS

If you have any comments or suggestions about this questionnaire, please feel free to write them below:

_____

_____

_____

_____

_____

_____

_____

APPENDIX VI: ISIS Individual Questionnaire T2

Questionnaire on the health and neighbourhoods of young adult Montrealers

Dear ISIS participant,

It has been two years since you completed the first ISIS questionnaire (how time flies!). We truly appreciate your interest in this project. Your ongoing participation is very important because it allows us to better understand the link between neighbourhoods and young adults' health in Montreal. Thanks to your participation we will be able to develop strategies to improve our city's neighbourhoods for the benefit of all its inhabitants.

This questionnaire is similar to the first, but includes new questions. It will allow us to assess if there have been changes in certain aspects of your life over the past two years. In particular, the questions concern the following subjects:

- Your health
- Your cigarette use
- Places where you get health care
- Your relationships and the scope of possibilities in your life
- The languages you speak and your religious beliefs
- Your studies and your work
- Your housing
- Your expenses
- Your neighbourhood
- Places where you spend time

We pledge to never publish any personal information that would make it possible to identify you. If there is any question you would rather not answer, please just go on to the next one.

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

- Most of the questions are multiple choice. Select the answer that applies to you.
- Choose only one answer for each question, unless the instructions say otherwise.
- On the next page you will find the consent form. Please read it carefully. At the bottom of the form you will be asked to decide whether you accept or refuse to participate in this study.
- Make sure to click on "validate" at the end of the questionnaire.

If you have any questions, please don't hesitate to contact us:
☎

QUESTIONS ABOUT ELIGIBILITY

A1. What is your home address?

NUMBER AND STREET NAME:

_____

CITY:

_____

PROVINCE:

_____

POSTAL CODE:

_____

A2. Does the location on the map match your home address?

If yes, click on **"Next"**.

If not, please correct your home address or locate your address by clicking on the map. When the location on the map matches your home address, click on **"Next"**.

A3. How long have you been living at your current address?

O Less than 1 year
O More than 1 year but less than 2 years
O Between 2 and 5 years
O More than 5 years

YOUR HEALTH

1. Compared to other people your age, would you say that, in general, your physical health is:

O Excellent
O Very good
O Pretty good
O Fair
O Poor
O I don't know

2. Compared to other people your age, would you say that, in general, your mental health is:

O Excellent
O Very good
O Pretty good
O Fair
O Poor
O I don't know

3. How do you feel about your life as a whole right now?

Please select a value from 0 to 10, where 0 means "Very dissatisfied" and 10 means "Very satisfied".

O 0 – Very dissatisfied
O 1
O 2
O 3
O 4
O 5
O 6
O 7
O 8
O 9
O 10 – Very satisfied

4. Are you able to…
[Please check <u>one answer per line</u>]

	Completely able	Somewhat able	Not very able	Not at all able	I don't know
Carry an 8-kg (18 lbs) weight up 3 flights of stairs (for example, 6 full bags of groceries)	O	O	O	O	O
Raise your upper body from a lying position without using your arms (sit-up)	O	O	O	O	O
Carry 2 heavy suitcases up 3 flights of stairs	O	O	O	O	O
Walk 20 minutes (about 2 kilometres or 1 mile) at a sustained pace without a break	O	O	O	O	O

	Completely able	Somewhat able	Not very able	Not at all able	I don't know
Run 6 minutes (about 1 kilometre or ½ mile) without a break	O	O	O	O	O
Run 30 minutes (about 5 kilometres or 3 miles) without a break	O	O	O	O	O
Touch the floor with your hands while sitting in a chair	O	O	O	O	O
Touch the floor with your hands while standing (without bending your knees)	O	O	O	O	O
Touch your knees with your head while standing	O	O	O	O	O
Stay balanced on one leg (at least 15 seconds) without holding on to anything	O	O	O	O	O
Do a somersault	O	O	O	O	O
Jump over a 1-meter (3-foot) high fence by supporting yourself on it	O	O	O	O	O

5. Do you suffer from one of the following health problems: chronic bronchitis, persistent cough or asthma?

O Yes
O No
O I don't know

YOUR CIGARETTE USE

6. In your life, have you smoked a total of 100 cigarettes or more (around 4 packs)?

O Yes → **go to question 8**
O No

7. Have you ever smoked an entire cigarette?

O Yes
O No → **go to question 33**

8. How old were you when you smoked an entire cigarette for the first time?

_____years

9. During the past 30 days (past month), have you smoked part or all of a cigarette?

O Yes
O No

10. Currently, do you smoke cigarettes every day, sometimes or never?

O Every day
O Sometimes → **go to question 18**
O Never → **go to question 28**

If you smoke every day

11. How old were you when you started smoking cigarettes every day?

_____years

12. Currently, how many cigarettes do you smoke each day?

_____cigarette(s) per day

13. How do you get your tobacco products (cigarettes, rolling tobacco, cigarillos)? Choose <u>all</u> the answers that apply to you.

O At the convenience store (dépanneur) or the tobacco store
O At the grocery store
O From friends, co-workers or other people you know
O From members of your family
O On an Indian reserve
O Other, specify: _____

14. In what form do you get cigarettes? Choose <u>all</u> the answers that apply to you.

O As singles
O By the pack
O As a carton
O In a plastic bag (Ziploc®-type)
O As rolling tobacco
O Other, specify: _____

15. Are you seriously considering quitting smoking in the next 30 days?

O Yes
O No

16. In the past 12 months, did you stop smoking for at least 24 hours because you were trying to quit?

O Yes
O No → **go to question 33**

17. How many times? (in the past 12 months, did you stop smoking for at least 24 hours because you were trying to quit.)

_____times → **go to question 33**

If you smoke sometimes

18. On the days when you smoke, how many cigarettes do you usually smoke?

_____cigarette(s) per day

19. In the past month, how many days did you smoke one cigarette or more?

_____ day(s)

20. How do you get your tobacco products (cigarettes, rolling tobacco, cigarillos)? Choose <u>all</u> the answers that apply to you.

O At the convenience store (dépanneur) or the tobacco store
O At the grocery store
O From friends, co-workers or other people you know
O From members of your family
O On an Indian reserve
O Other, specify: _____

21. In what form do you get cigarettes? Choose <u>all</u> the answers that apply to you.

O As singles
O By the pack
O As a carton
O In a plastic bag (Ziploc®-type)
O As rolling tobacco
O Other, specify: _____

22. Have you ever smoked cigarettes every day?

O Yes
O No → **go to question 25**

23. How old were you when you started smoking cigarettes every day?

_____years

24. When did you stop smoking every day?

O Less than 1 year ago
O From 1 year ago to less than 2 years ago
O From 2 years ago to less than 3 years ago
O 3 or more years ago

25. Are you seriously considering quitting smoking in the next 30 days?

O Yes
O No

26. In the past 12 months, did you stop smoking for at least 24 hours because you were trying to quit?

O Yes
O No → **go to question 33**

27. How many times? (in the past 12 months, did you stop smoking for at least 24 hours because you were trying to quit.)

_____times → **go to question 33**

If you never smoke

28. Have you ever smoked cigarettes every day?

O Yes
O No → **go to question 32**

29. How old were you when you started smoking cigarettes every day?

_____years

30. When did you stop smoking every day?

O Less than 1 year ago
O From 1 year ago to less than 2 years ago → **go to question 32**
O From 2 years ago to less than 3 years ago → **go to question 32**
O 3 or more years ago → **go to question 32**

31. How many times? (in the past 12 months, did you stop smoking for at least 24 hours because you were trying to quit.)

_____times

32. When was the last time you smoked a cigarette?

O Less than 1 year ago
O From 1 year ago to less than 2 years ago
O From 2 years ago to less than 3 years ago
O 3 or more years ago

33. How many of your friends smoke?

O None
O One or a few
O About half
O Most
O All
O I don't know

34. How many members of your immediate family smoke?

O None
O One or a few
O About half
O Most
O All
O I don't know

PLACES WHERE YOU GET HEALTH CARE

35. Do you have a regular medical doctor (also known as a family doctor)?

O Yes
O No
O I don't know

36. Is there a place that you usually go to when you are sick or need advice about your health?

O Yes
O No → **go to question 40**
O I don't know

37. What kind of place is it?

(If there is more than one usual place, please choose the place that you go to most often)

O Doctor's office
O Community health centre / CLSC
O Walk-in clinic
O Appointment clinic
O Telephone health line (for example, Health-Line, TeleCare, Info-Santé) →**go to question 40**
O Hospital emergency room
O Hospital outpatient clinic
O Other

38. What is the name of this place?

_____

39. On the map, locate the place where you usually go when you are sick or need advice about your health.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub message: "Attention: You have not identified a location."

Two buttons: "Continue without locating a place" and "Locate a place"

YOUR RELATIONSHIPS AND THE SCOPE OF POSSIBILITIES IN YOUR LIFE

40. What is your marital status?

O Single
O Married
O Common-law or in a couple
O Separated or divorced
O Widowed

41. In general, how satisfied are you with your relationships with your friends?

O Very satisfied
O Somewhat satisfied
O Somewhat dissatisfied
O Very dissatisfied

42. I feel the scope (possibilities)...

Please check one answer per line

	Very good	Good	Somewhat good	Neutral	Somewhat bad	Bad	Very bad
to seek happiness in my life is…	O	O	O	O	O	O	O
to achieve things in my life is…	O	O	O	O	O	O	O
to live a healthy life is…	O	O	O	O	O	O	O
for intellectual stimulation in my life is…	O	O	O	O	O	O	O
to form satisfying social relations in my life is…	O	O	O	O	O	O	O
for being in pleasant environments (taking home, work, and leisure together) in my life is…	O	O	O	O	O	O	O
to act with personal integrity in my life is…	O	O	O	O	O	O	O
of my options are…	O	O	O	O	O	O	O

THE LANGUAGES YOU SPEAK AND YOUR RELIGIOUS BELIEFS

43. What language(s) do you speak most often at home?

Choose all the answers that apply to you if these languages are spoken equally often at home.

O French
O English
O Other, specify: _____

44. Do you identify with any religion?

O Yes
O No → **go to question 47**

45. How important is your religion to you?

O Not at all important
O Not very important
O Somewhat important
O Very important

46. In the past 12 months, how often did you attend or participate in religious activities, services or meetings, aside from weddings or funerals?

O At least once a week
O At least once a month
O At least 3 times a year
O Once or twice a year
O Never

YOUR STUDIES AND YOUR WORK

47. What is the highest level of education you have <u>completed</u> (this does not include current studies)?

O No school, or only kindergarten
O Elementary school
O Secondary 4 or less (10th grade or less)
O Secondary 5 (11th grade)
O Diploma or certificate of studies in a technical program at a CEGEP, a trade school, a commercial or private college, a technical institute, or a nursing school
O Diploma or certificate of studies in a general program at a CEGEP
O University undergraduate certificate
O Bachelor's degree
O Degree in medicine, dentistry, veterinary medicine, optometry or chiropracy
O University graduate certificate
O Master's degree
O Earned doctorate

The following four questions are regarding the education levels and age of your mother and of your father or of the person who took the role of your mother and/or of your father while you were growing up.

48. What was the highest level of education that your mother attained (this does not include current studies)?

O No school, or only kindergarten
O Elementary school
O Secondary 4 or less (10th grade or less)
O Secondary 5 (11th grade)
O Diploma or certificate of studies in a technical program at a CEGEP, a trade school, a commercial or private college, a technical institute, or a nursing school
O Diploma or certificate of studies in a general program at a CEGEP
O University undergraduate certificate
O Bachelor's degree
O Degree in medicine, dentistry, veterinary medicine, optometry or chiropracy
O University graduate certificate
O Master's degree
O Earned doctorate
O I don't know

49. What was the highest level of education that your father attained (this does not include current studies)?

O No school, or only kindergarten
O Elementary school
O Secondary 4 or less (10th grade or less)
O Secondary 5 (11th grade)
O Diploma or certificate of studies in a technical program at a CEGEP, a trade school, a commercial or private college, a technical institute, or a nursing school
O Diploma or certificate of studies in a general program at a CEGEP
O University undergraduate certificate
O Bachelor's degree
O Degree in medicine, dentistry, veterinary medicine, optometry or chiropracy
O University graduate certificate
O Master's degree
O Earned doctorate
O I don't know

50. How old is your mother?
(If your mother has passed away, please indicate the age she would have been today)

_____years

51. How old is your father?
(If your father has passed away, please indicate the age he would have been today)

_____years

52. If needed, can anyone in your family put you in contact with people who can help you improve your employment situation?

O Most probably
O Probably
O Not very probably
O Not at all probably
O Does not apply (no contact, deceased, etc.)
O I don't know

YOUR HOUSING

53. Including yourself, how many people currently live or reside at your address?

O 1 → **go to question 55**
O 2
O 3
O 4
O 5
O 6
O 7
O 8
O 9
O 10 or more

54. Who do you currently live with? Choose all the answers that apply to you.

I live…

O With both my parents
O With one of my parents
O With my brothers and sisters
O With grandparents or other members of my family
O With my partner/spouse
O With my children or my partner/spouse's children
O With roommates, friends or other people I know
O Other

55. Who owns the home you live in?

I am / a member of my family is the …

O Owner of the home
O Tenant in the home

56. How many rooms are there in the home you live in?

Please include all the rooms except the bathroom and hallway(s).

O 1
O 2
O 3
O 4
O 5
O 6
O 7
O 8
O 9 or more

YOUR EXPENSES

57. With the following questions we want to find out whether, in the past 12 months, you ever didn't have enough money to pay for various things needed for daily life. If this has happened to you, we would like to know how serious that situation was.

On each line, please check one answer in the first section; if your answer is "yes", please also check one box in the second section

	In the past 12 months, did you, or the person responsible for this expense, ever not have enough money to…			If yes, how serious was this lack of money?				
	Yes	No	I don't know	Not at all serious	A little serious	Somewhat serious	Very serious	I don't know
… pay the rent or mortgage?	O	O	O	O	O	O	O	O
… pay for electricity, hot water, or heat?	O	O	O	O	O	O	O	O
… buy food?	O	O	O	O	O	O	O	O

58. If you needed money urgently, could you borrow $500 quickly from the following persons?

Please check one answer on each line

	Yes	No	Does not apply (no contact, deceased, etc.)	I don't know
Your mother	O	O	O	O
Your father	O	O	O	O
Your partner/spouse	O	O	O	O
A brother or sister	O	O	O	O
A grandparent	O	O	O	O
A friend	O	O	O	O
A co-worker	O	O	O	O
Other	O	O	O	O

YOUR NEIGHBOURHOOD

The following questions are about how you perceive your residential neighbourhood to be.

59. In your neighbourhood, how many people can you say hello to on a regular basis?

O No one
O A few people
O Several people
O Most people

Please indicate how much you agree or disagree with the following three statements:

60. I can trust the people in my neighbourhood.

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

61. I feel safe going out alone at night in my neighbourhood.

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

62. The people in my neighbourhood help each other out (for example, lending tools, picking up mail, letting others use their telephone, etc.).

O Strongly agree
O Somewhat agree
O Neither agree nor disagree
O Somewhat disagree
O Strongly disagree
O I don't know

63. To what extent do you agree with the following statements regarding the neighbourhood where you live?

Please check one answer per line

	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	I don't know
There are enough businesses (grocery stores, shops, cafés, etc.) in the neighbourhood where I live	O	O	O	O	O
There are enough sport and recreation areas in the neighbourhood where I live	O	O	O	O	O
There are enough health care services in the neighbourhood where I live	O	O	O	O	O

64. The previous questions were about your neighbourhood (the people who live there and the services you find there). To help us understand what geographic area you are referring to, draw the boundaries of your neighbourhood as you perceive them to be on the map.

Click on the map with the mouse to draw the boundary points outlining your neighbourhood.

Feel free to adjust the zoom levels and to move the map to comfortably draw the boundaries of your neighbourhood.

Main message: "Do you want to go to the next question?"

PLACES WHERE YOU SPEND TIME

Your neighbourhood and the places where you spend time might affect your health. The following questions are about the places where you spend time on a regular basis. For each category, please identify as precisely as possible on the map the place where you do the activity in question. For some types of activities you can indicate two places, starting with the one you go to most often.

Studies

65. Are you currently a student (either full-time, part-time, or in an internship program)?

O Yes
O No → **go to question 70**

66. What is the name of the institution you attend for your studies, including the campus and the building (if these apply)?

NAME OF THE INSTITUTION:
_____

NAME OF THE CAMPUS :
_____

NAME OF THE BUILDING :
_____

67. On the map, locate the educational institution you attend for your studies

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

68. In a typical 7-day week, how many hours do you spend at this place for school purposes?

_____hour(s) per week

69. To what extent do you agree with the following statements regarding the place where you go to study:

	Strongly agree	Somewhat agree	Strongly disagree	Somewhat disagree	I don't know
There are enough businesses (grocery stores, shops, cafés, etc.) near the place where I study	O	O	O	O	O
There are enough sport and recreation areas near the place where I study	O	O	O	O	O
There are enough health care services near the place where I study	O	O	O	O	O

Work

70. Are you currently in paid employment?

This includes full-time work or part-time work, whether you are an employee, self-employed, a freelancer, on contract, in an internship, on vacation, on parental leave, on sick leave or work-accident leave, on strike or lock-out situation.

O Yes
O No → **go to question 82**

71. If you are currently in paid employment, do you work…

Choose all the answers that apply to you.

O Full-time
O Part-time
O On contract or freelance

72. Where do you work? You can name up to two jobs or workplaces, if necessary.

Job or workplace 1

NAME OF COMPANY OR EMPLOYER:

_____

73. Usually, do you work mostly :

O from home → **go to question 7**
O on the road → **go to question 77**
O neither at home nor on the road

74. On the map, locate your main workplace.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

75. In a typical 7-day week, how many hours do you spend at this place for work purposes?

_____hour(s) per week

76. To what extent do you agree with the following statements regarding your workplace:

	Strongly agree	Somewhat agree	Strongly disagree	Somewhat disagree	I don't know
There are enough businesses (grocery stores, shops, cafés, etc.) near my workplace	O	O	O	O	O
There are enough sport and recreation areas near my workplace	O	O	O	O	O
There are enough health care services near my workplace	O	O	O	O	O

77. Do you work anywhere else, either as part of this job, or for another job?

O Yes, I have another job
O Yes, I work somewhere else as part of this same job → **go to question 79**
O No, I always work in the same place → **go to question 82**

Job or workplace 2

78. Where do you work mostly?

NAME OF COMPANY OR EMPLOYER:

_____

79. Usually, do you work :

O from home → **go to question 81**
O on the road → **go to question 82**
O neither at home nor on the road

80. On the map, locate your second workplace.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

81. In a typical 7-day week, how many hours do you spend at this place for work purposes?

_____hour(s) per week

Grocery shopping

82. In your household, who does the grocery shopping?

O Only you
O Partly you
O Someone other than you → **go to question 90**

83. When you are the one doing the grocery shopping, where do you go? You can name up to two places (if necessary), starting with the place you go to most often.

Primary place:

NAME OF THE PLACE (example: “Such-and-such” grocery store, “Such-and-such” convenience store, “Such-and-such” public market) :

_____

84. On the map, locate the place where you do your grocery shopping most often.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?”

Sub-message: “You have not identified a location."

85. In the past month, how many times have you gone to this place to buy groceries?

_____time(s) in the past month

86. Is there another place where you regularly do your grocery shopping?

O Yes
O No → **go to question 90**

Second place

87. What is the name of this second place where you do your grocery shopping?

NAME OF THE PLACE (example: “Such-and-such” grocery store, “Such-and-such” convenience store, “Such-and-such” public market) :

_____

88. On the map, locate the second place where you do your grocery shopping.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?”

Sub-message: “You have not identified a location."

89. In the past month, how many times have you gone to this place to buy groceries?

_____time(s) in the past month

Physical activities and sports

90. Do you regularly engage in physical activity or sports?

O Yes
O No → **go to question 95**

91. Do you usually engage in physical activity or sports in a particular place?

O Yes, I usually do these types of activities at home → **go to question 94**
O Yes, I usually do these types of activities other than at home, in one specific place that I go to regularly
O No, I do not do these types of activities at one specific place on a regular basis → **go to question 95**

92. Where do you usually engage in physical activity or sports?

NAME OF THE PLACE :
_____

93. On the map, locate the place where you usually engage in physical activity or sports.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

94. In a typical 7-day week, how many hours do you spend at this place doing physical activity or sports?

_____hour(s) per week

Leisure activities

95. Do you regularly engage in leisure activities?

O Yes
O No → **go to question 100**

96. Do you usually engage in leisure activities in a particular place?

O Yes, I usually do these types of activities at home → **go to question 99**
O Yes, I usually do these types of activities other than at home, in one specific place that I go to regularly
O No, I do not do these types of activities at one specific place on a regular basis → **go to question 100**

97. Where do you usually engage in leisure activities?

NAME OF THE PLACE :
_____

98. On the map, locate the place where you usually engage in leisure activities.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

99. In a typical 7-day week, how many hours do you spend at this place doing leisure activities?

_____hour(s) per week

Other places where you spend time

100. Aside from the places you've already mentioned, are there other places where you regularly spend time?

These could be public places or private homes (yours or someone else's). They could be places where you spend time with friends, your partner/spouse or members of your family, or where you engage in sports or leisure, or where you are doing a study or professional internship, volunteering, or engaging in social or religious activities.

O Yes
O No → **go to question 110**

101. What is the name of this place where you regularly spend time? You will be able to name up to two places (if necessary), starting with the one where you spend the most time.

NAME OF THE PLACE :
_____

102. On the map, locate the place where you regularly spend time.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

103. In a typical 7-day week, how many hours do you spend at this place?

_____hour(s) per week

104. What do you usually do there?

_____

105. Is there another place where you regularly spend time?

O Yes
O No → **go to question 110**

106. What is the name of this other place where you regularly spend time?

NAME OF THE PLACE :
_____

107. On the map, locate another place where you regularly spend time.

Type the address, search by keyword or click directly on the map. Main

message: "Do you want to go to the next question?"

Sub-message: "You have not identified a location."

108. In a typical 7-day week, how many hours do you spend at this place?

_____hour(s) per week

109. What do you usually do there?

_____

The following three questions are about your access to different means of transportation.

110. Do you have a driver's license?

O Yes
O No

111. Do you own a car, or have a car at your disposal (for example, the car of a friend or family member, or membership in a car sharing system such as *Communauto*, etc.)?

O Yes
O No

112. Do you have a monthly public transit pass (bus, metro and/or train)?

O Yes
O No

A FEW LAST QUESTIONS

Even though healthcare expenses are partly covered by Quebec's public health insurance program, there continues to be a link between health status and income. We would appreciate if you could answer the following two questions so that we can study this link. Please be assured that all the information collected as part of this study will be treated strictly confidentially.

113. Approximately what was your total personal income LAST YEAR, before tax deductions?

Please include any financial aid you may have received (for example, a scholarship, employment insurance benefits, CSST or other insurance benefits, etc.)

O No personal income
O $1 to $4,999
O $5,000 to $9,999
O $10,000 to $14,999
O $15,000 to $19,999
O $20,000 to $29,999
O $30,000 to $39,999
O $40,000 to $49,999
O $50,000 to $99,999
O $100,000 and more
O I don't know

114. In the past 12 months, have you received any social assistance, that is, financial aid provided as a last resort (also known as welfare assistance)?

O Yes
O No

END OF THE QUESTIONNAIRE

SELECT YOUR GIFT CERTIFICATE

As a way to thank you for completing this questionnaire, the ISIS team will give you a $10 gift certificate redeemable at one of the following retailers. Please choose the retailer for which you would like a gift certificate (only one selection per participant).

O iTunes
O Renaud-Bray
O Cineplex Odeon

YOUR CONTACT INFORMATION

We might contact you again during the next few years to share news and findings of the study. We will contact you a maximum of three times per year, and you can choose at any time to stop these contacts. We would therefore appreciate it very much if you would give us your email address and telephone number, as well as the contact information of a person close to you, so that we can make sure to reach you for the next phase of the study. This person will only be contacted if we are having trouble reaching you.

Your email address: _____

Your telephone number: _____

The name of a person close to you who we can contact if we are having trouble reaching you:

_____

Your relationship with this person: _____

This person's email address: _____

This person's telephone number: _____

☐ I will inform this person about this study and the reasons why I gave his/her contact information

COMMENTS

If you have any comments or suggestions about this questionnaire, please feel free to write them below:

_____

_____

_____

_____

_____

_____

APPENDIX VII: Model Equations

NULL MODEL EQUATIONS

3-Level Null Models

Prob Smoking Behaviour Pattern(1) = $1|\pi_{jk}] = \phi_{1ijk}$
Prob Smoking Behaviour Pattern(2) = $1|\pi_{jk}] = \phi_{2ijk}$
Prob Smoking Behaviour Pattern(3) = $1|\pi_{jk}] = \phi_{3ijk}$
Prob Smoking Behaviour Pattern(4) = $1|\pi_{jk}] = \phi_{4ijk} = 1-\phi_{1ijk}-\phi_{2ijk}-\phi_{3ijk}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0jk(1)}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0jk(2)}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0jk(3)}$

Level-2 Model
$\pi_{0jk(1)} = \beta_{00k(1)} + r_{0jk(1)}$
$\pi_{0jk(2)} = \beta_{00k(2)}$
$\pi_{0jk(3)} = \beta_{00k(3)}$

Level-3 Model
$\beta_{00k(1)k} = \gamma_{000(1)} + u_{00k(1)k}$
$\beta_{00k(2)k} = \gamma_{000(2)} + u_{00k(2)k}$
$\beta_{00k(3)k} = \gamma_{000(3)} + u_{00k(3)k}$

2-Level Null Models

Prob Smoking Behaviour Pattern(1) = $1|\pi_{j}] = \phi_{1ij}$
Prob Smoking Behaviour Pattern(2) = $1|\pi_{j}] = \phi_{2ij}$
Prob Smoking Behaviour Pattern(3) = $1|\pi_{j}] = \phi_{3ij}$
Prob Smoking Behaviour Pattern(4) = $1|\pi_{j}] = \phi_{4ij} = 1-\phi_{1ij}-\phi_{2ij}-\phi_{3ij}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0j(1)}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0j(2)}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0j(3)}$

Level-2 Model
$\pi_{0j(1)} = \beta_{0j(1)} + r_{0j(1)}$
$\pi_{0j(2)} = \beta_{0j(2)}$
$\pi_{0j(3)} = \beta_{0j(3)}$

Null Model Variance and Percentage of Variation Explained at Area Levels

Article 1

Level-2 Variance: 0.00018; p=>0.500
Level-3 Variance: 0.04027; p=0.009
Percentage of variation explained at area levels: 81.3%

Article 2

Level-2 Variance: 0.00089; p=>0.500
Level-3 Variance: 0.05737; p=0.037
Percentage of variation explained at area levels: 51.1%

Article 3

Level-2 Variance: 0.16213; p=>0.500
Percentage of variation explained at area levels: 76.5%

EQUATIONS USED IN ARTICLE 1

3-Level Models with Individual-Level Predictors

Level-1 Model

Prob Smoking Behaviour Pattern(1)= $1|\pi_{jk}] = \phi_{1ijk}$
Prob Smoking Behaviour Pattern(2)= $1|\pi_{jk}] = \phi_{2ijk}$
Prob Smoking Behaviour Pattern(3)= $1|\pi_{jk}] = \phi_{3ijk}$
Prob Smoking Behaviour Pattern(4)= $1|\pi_{jk}] = \phi_{4ijk} = 1-\phi_{1ijk}-\phi_{2ijk}-\phi_{3ijk}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0jk(1)}+\pi_{1jk(1)}*Age_{ijk}+\pi_{2jk(1)}*Sex_{ijk}+\pi_{3jk(1)}*Education_{ijk}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0jk(2)}+\pi_{1jk(2)}*Age_{ijk}+\pi_{2jk(2)}*Sex_{ijk}+\pi_{3jk(2)}*Education_{ijk}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0jk(3)}+\pi_{1jk(3)}*Age_{ijk}+\pi_{2jk(3)}*Sex_{ijk}+\pi_{3jk(3)}*Education_{ijk}$

Level-2 Model

$\pi_{0jk(1)} = \beta_{00k(1)} + r_{0jk(1)}$
$\pi_{1jk(1)} = \beta_{10k(1)}$
$\pi_{2jk(1)} = \beta_{20k(1)}$
$\pi_{3jk(1)} = \beta_{30k(1)}$
$\pi_{0jk(2)} = \beta_{00k(2)}$
$\pi_{1jk(2)} = \beta_{10k(2)}$
$\pi_{2jk(2)} = \beta_{20k(2)}$
$\pi_{3jk(2)} = \beta_{30k(2)}$
$\pi_{0jk(3)} = \beta_{00k(3)}$
$\pi_{1jk(3)} = \beta_{10k(3)}$
$\pi_{2jk(3)} = \beta_{20k(3)}$
$\pi_{3jk(3)} = \beta_{30k(3)}$

Level-3 Model

$\beta_{00k(1)k} = \gamma_{000(1)}+u_{00k(1)k}$
$\beta_{10k(1)k} = \gamma_{100(1)}$
$\beta_{20k(1)k} = \gamma_{200(1)}$
$\beta_{30k(1)k} = \gamma_{300(1)}$
$\beta_{00k(2)k} = \gamma_{000(2)}+ u_{00k(2)k}$
$\beta_{10k(2)k} = \gamma_{100(2)}$

$\beta_{20k(2)k} = \gamma_{300(2)}$
$\beta_{30k(2)k} = \gamma_{300(2)}$
$\beta_{00k(3)k} = \gamma_{100(3)} + u_{00k(3)k}$
$\beta_{10k(3)k} = \gamma_{100(3)}$
$\beta_{20k(3)k} = \gamma_{200(3)}$
$\beta_{30k(3)k} = \gamma_{300(3)}$

3-Level Univariate Models with Level 2 Predictors

Level-1 Model

Prob Smoking Behaviour Pattern(1)= $1|\pi_{jk}] = \phi_{1ijk}$
Prob Smoking Behaviour Pattern(2)= $1|\pi_{jk}] = \phi_{2ijk}$
Prob Smoking Behaviour Pattern(3)= $1|\pi_{jk}] = \phi_{3ijk}$
Prob Smoking Behaviour Pattern(4)= $1|\pi_{jk}] = \phi_{4ijk} = 1-\phi_{1ijk}-\phi_{2ijk}-\phi_{3ijk}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0jk(1)}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0jk(2)}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0jk(3)}$

Level-2 Model

$\pi_{0jk(1)} = \beta_{00k(1)}+\beta_{01k(1)}$*Residential Environment Feature$_{jk}+r_{0jk(1)}$
$\pi_{0jk(2)} = \beta_{00k(2)}+\beta_{01k(2)}$*Residential Environment Feature$_{jk}$
$\pi_{0jk(3)} = \beta_{00k(3)}+\beta_{01k(3)}$*Residential Environment Feature$_{jk}$

Level-3 Model

$\beta_{00k(1)k} = \gamma_{000(1)}+u_{00k(1)k}$
$\beta_{01k(1)k} = \gamma_{010(1)}$
$\beta_{00k(2)k} = \gamma_{000(2)}+u_{00k(2)k}$
$\beta_{01k(2)k} = \gamma_{010(2)}$
$\beta_{00k(3)k} = \gamma_{000(3)}+u_{00k(3)k}$
$\beta_{01k(3)k} = \gamma_{010(3)}$

3-Level Univariate Models with Level 3 Predictors

Level-1 Model

Prob Smoking Behaviour Pattern(1)= $1|\pi_{jk}] = \phi_{1ijk}$
Prob Smoking Behaviour Pattern(2)= $1|\pi_{jk}] = \phi_{2ijk}$
Prob Smoking Behaviour Pattern(3)= $1|\pi_{jk}] = \phi_{3ijk}$
Prob Smoking Behaviour Pattern(4)= $1|\pi_{jk}] = \phi_{4ijk} = 1-\phi_{1ijk}-\phi_{2ijk}-\phi_{3ijk}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0jk(1)}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0jk(2)}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0jk(3)}$

Level-2 Model

$\pi_{0jk(1)} = \beta_{00k(1)} + r_{0jk(1)}$
$\pi_{0jk(2)} = \beta_{00k(2)}$
$\pi_{0jk(3)} = \beta_{00k(3)}$

Level-3 Model

$\beta_{00k(1)k} = \gamma_{000(1)} + \gamma_{001(1)}(\text{Residential Environment Feature}_k) + u_{00k(1)k}$
$\beta_{00k(2)k} = \gamma_{000(2)} + \gamma_{001(2)}(\text{Residential Environment Feature}_k) + u_{00k(2)k}$
$\beta_{00k(3)k} = \gamma_{000(3)} + \gamma_{001(3)}(\text{Residential Environment Feature}_k) + u_{00k(3)k}$

3-Level Fully-Adjusted Models (example with Level 2 Predictors)

Level-1 Model

Prob Smoking Behaviour Pattern(1)= $1|\pi_{jk}] = \phi_{1ijk}$
Prob Smoking Behaviour Pattern(2)= $1|\pi_{jk}] = \phi_{2ijk}$
Prob Smoking Behaviour Pattern(3)= $1|\pi_{jk}] = \phi_{3ijk}$
Prob Smoking Behaviour Pattern(4)= $1|\pi_{jk}] = \phi_{4ijk} = 1 - \phi_{1ijk} - \phi_{2ijk} - \phi_{3ijk}$

$\log[\phi_{1ijk}/\phi_{4ijk}] = \pi_{0jk(1)} + \pi_{1jk(1)} * \text{Age}_{ijk} + \pi_{2jk(1)} * \text{Sex}_{ijk} + \pi_{3jk(1)} * \text{Education}_{ijk}$
$\log[\phi_{2ijk}/\phi_{4ijk}] = \pi_{0jk(2)} + \pi_{1jk(2)} * \text{Age}_{ijk} + \pi_{2jk(2)} * \text{Sex}_{ijk} + \pi_{3jk(2)} * \text{Education}_{ijk}$
$\log[\phi_{3ijk}/\phi_{4ijk}] = \pi_{0jk(3)} + \pi_{1jk(3)} * \text{Age}_{ijk} + \pi_{2jk(3)} * \text{Sex}_{ijk} + \pi_{3jk(3)} * \text{Education}_{ijk}$

Level-2 Model

$\pi_{0jk(1)} = \beta_{00k(1)} + \beta_{01k(1)} * \text{Residential Environment Feature}_{jk} + \beta_{02k(1)} * \text{Material Deprivation}_{jk} + r_{0jk(1)}$
$\pi_{1jk(1)} = \beta_{10k(1)}$
$\pi_{2jk(1)} = \beta_{20k(1)}$
$\pi_{0jk(2)} = \beta_{00k(2)} + \beta_{01k(2)} * \text{Residential Environment Feature}_{jk} + \beta_{02k(2)} * \text{Material Deprivation}_{jk}$
$\pi_{1jk(2)} = \beta_{10k(2)}$
$\pi_{2jk(2)} = \beta_{20k(2)}$
$\pi_{0jk(3)} = \beta_{00k(3)} + \beta_{01k(2)} * \text{Residential Environment Feature}_{jk} + \beta_{02k(3)} * \text{Material Deprivation}_{jk}$
$\pi_{1jk(3)} = \beta_{10k(3)}$
$\pi_{2jk(3)} = \beta_{20k(3)}$

Level-3 Model

$\beta_{00k(1)k} = \gamma_{000(1)} + u_{00k(1)k}$
$\beta_{01k(1)k} = \gamma_{010(1)}$
$\beta_{02k(1)k} = \gamma_{020(1)}$
$\beta_{10k(1)k} = \gamma_{100(1)}$
$\beta_{20k(1)k} = \gamma_{200(1)}$
$\beta_{00k(2)k} = \gamma_{000(2)} + u_{00k(2)k}$
$\beta_{01k(2)k} = \gamma_{010(2)}$
$\beta_{02k(2)k} = \gamma_{020(2)}$
$\beta_{10k(2)k} = \gamma_{100(2)}$
$\beta_{20k(2)k} = \gamma_{200(2)}$
$\beta_{00k(3)k} = \gamma_{000(3)} + u_{00k(3)k}$

$\beta_{01k(3)k} = \gamma_{010(3)}$
$\beta_{02k(3)k} = \gamma_{020(3)}$
$\beta_{10k(3)k} = \gamma_{100(3)}$
$\beta_{20k(3)k} = \gamma_{200(3)}$

EQUATIONS USED IN ARTICLE 2

2-Level Models with Individual-Level Predictors

Level-1 Model

Prob Smoking Behaviour Pattern$_{ij}$=1|β_j) = ϕ_{ij}
$\log[\phi_{ij}/(1-\phi_{ij})] = \eta_{ij}$
$\eta_{ij} = \beta_{0j}+\beta_{1j}$*Age$_{ij}+\beta_{2j}$*Sex$_{ij}+\beta_{3j}$*Education$_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00}+u_{0j}$
$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30}$

Mixed Model

$\eta_{ij} = \gamma_{00}+\gamma_{10}$*Age$_{ij}+\gamma_{20}$*Sex$_{ij}+\gamma_{30}$*Education$_{ij}+u_{0j}$

2-Level Univariate Models with Level 2 Predictors

Level-1 Model

Prob Smoking Behaviour Pattern$_{ij}$=1|β_j) = ϕ_{ij}
$\log[\phi_{ij}/(1-\phi_{ij})] = \eta_{ij}$
$\eta_{ij} = \beta_{0j}$

Level-2 Model

$\beta_{0j} = \gamma_{00}+\gamma_{01}$*Residential Environment Feature$_j+u_{0j}$

Mixed Model

$\eta_{ij} = \gamma_{00}+\gamma_{01}$*Residential Environment Feature$_j+u_{0j}$

2-Level Fully-Adjusted Models

Level-1 Model

Prob Smoking Behaviour Pattern$_{ij}$=1|β_j) = ϕ_{ij}
$\log[\phi_{ij}/(1-\phi_{ij})] = \eta_{ij}$
$\eta_{ij} = \beta_{0j}+\beta_{1j}$*Age$_{ij}+\beta_{2j}$*Sex$_{ij}+\beta_{3j}$*Education$_{ij+}$ β_{4j}*Daily Smoking$_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00}+\gamma_{01}$* Residential Environment Feature$_j+\gamma_{02}$*Material Deprivation$_j+u_{0j}$
$\beta_{1j} = \gamma_{10}$
$\beta_{2j} = \gamma_{20}$
$\beta_{3j} = \gamma_{30}$
$\beta_{4j} = \gamma_{40}$

Mixed Model

$\eta_{ij} = \gamma_{00}+ \gamma_{01}$* Residential Environment Feature$_j+\gamma_{02}$*Material Deprivation$_j$ +
γ_{10}*Age$_{ij}+\gamma_{20}$*Sex$_{ij}+\gamma_{30}$*Education$_{ij}+\gamma_{40}$*Daily Smoking$_j+u_{0j}$

EQUATIONS USED IN ARTICLE 3

2-Level Models with Individual-Level Predictors

Level-1 Model

Prob Smoking Behaviour Pattern(1)= $1|\beta_j] = \phi_{1ij}$
Prob Smoking Behaviour Pattern(2)= $1|\beta_j] = \phi_{2ij}$
Prob Smoking Behaviour Pattern(3)= $1|\beta_j] = \phi_{3ij}$
Prob Smoking Behaviour Pattern(4)= $1|\beta_j] = \phi_{4ij}$
Prob Smoking Behaviour Pattern(5)= $1|\beta_j] = \phi_{5ij} = 1-\phi_{1ij}-\phi_{2ij}-\phi_{3ij}-\phi_{4ij}$

$\log[\phi_{1ij}/\phi_{5ij}] = \beta_{0j(1)}+ \beta_{1j(1)}$*Age$_{ij}+\beta_{2j(1)}$*Sex$_{ij}+\beta_{3j(1)}$*Education$_{ij}$
$\log[\phi_{2ij}/\phi_{5ij}] = \beta_{0j(2)}+ \beta_{1j(2)}$*Age$_{ij}+\beta_{2j(2)}$*Sex$_{ij}+\beta_{3j(2)}$*Education$_{ij}$
$\log[\phi_{3ij}/\phi_{5ij}] = \beta_{0j(3)}+ \beta_{1j(3)}$*Age$_{ij}+\beta_{2j(3)}$*Sex$_{ij}+\beta_{3j(3)}$*Education$_{ij}$
$\log[\phi_{4ij}/\phi_{5ij}] = \beta_{0j(4)}+ \beta_{1j(4)}$*Age$_{ij}+\beta_{2j(4)}$*Sex$_{ij}+\beta_{3j(4)}$*Education$_{ij}$

Level-2 Model

$\beta_{0(1)} = \gamma_{00(1)}$
$\beta_{1(1)} = \gamma_{10(1)}$
$\beta_{2(1)} = \gamma_{20(1)}$
$\beta_{3(1)} = \gamma_{30(1)}$

$\beta_{0(2)} = \gamma_{00(2)}$
$\beta_{1(2)} = \gamma_{10(2)}$
$\beta_{2(2)} = \gamma_{20(2)}$
$\beta_{3(2)} = \gamma_{30(2)}$

$\beta_{0(3)} = \gamma_{00(3)}$
$\beta_{1(3)} = \gamma_{10(3)}$
$\beta_{2(3)} = \gamma_{20(3)}$
$\beta_{3(3)} = \gamma_{30(3)}$

$\beta_{0(4)} = \gamma_{00(4)}$
$\beta_{1(4)} = \gamma_{10(4)}$
$\beta_{2(4)} = \gamma_{20(4)}$
$\beta_{3(4)} = \gamma_{30(4)}$

2-Level Univariate Models with Level 2 Predictors

Level-1 Model

$\text{Prob Smoking Behaviour Pattern(1)}= 1|\beta_j] = \phi_{1ij}$
$\text{Prob Smoking Behaviour Pattern(2)}= 1|\beta_j] = \phi_{2ij}$
$\text{Prob Smoking Behaviour Pattern(3)}= 1|\beta_j] = \phi_{3ij}$
$\text{Prob Smoking Behaviour Pattern(4)}= 1|\beta_j] = \phi_{4ij}$
$\text{Prob Smoking Behaviour Pattern(5)}= 1|\beta_j] = \phi_{5ij} = 1-\phi_{1ij}-\phi_{2ij}-\phi_{3ij}-\phi_{4ij}$

$\log[\phi_{1ij}/\phi_{5ij}] = \beta_{0j(1)}+ \beta_{1j(1)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{2ij}/\phi_{5ij}] = \beta_{0j(2)}+ \beta_{1j(2)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{3ij}/\phi_{5ij}] = \beta_{0j(3)}+ \beta_{1j(3)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{4ij}/\phi_{5ij}] = \beta_{0j(4)}+ \beta_{1j(4)}*\text{Residential Environment Exposure}_{ij}$

Level-2 Model

$\beta_{0(1)} = \gamma_{00(1)}+u_{0j(1)}$
$\beta_{1(1)} = \gamma_{10(1)}$
$\beta_{0(2)} = \gamma_{00(2)}$
$\beta_{1(2)} = \gamma_{10(2)}$
$\beta_{0(3)} = \gamma_{00(3)}$
$\beta_{1(3)} = \gamma_{10(3)}$
$\beta_{0(4)} = \gamma_{00(4)}$
$\beta_{1(4)} = \gamma_{10(4)}$

2-Level Fully-Adjusted Models

Level-1 Model

$\text{Prob Smoking Behaviour Pattern(1)}= 1|\beta_j] = \phi_{1ij}$
$\text{Prob Smoking Behaviour Pattern(2)}= 1|\beta_j] = \phi_{2ij}$
$\text{Prob Smoking Behaviour Pattern(3)}= 1|\beta_j] = \phi_{3ij}$
$\text{Prob Smoking Behaviour Pattern(4)}= 1|\beta_j] = \phi_{4ij}$
$\text{Prob Smoking Behaviour Pattern(5)}= 1|\beta_j] = \phi_{5ij} = 1-\phi_{1ij}-\phi_{2ij}-\phi_{3ij}-\phi_{4ij}$

$\log[\phi_{1ij}/\phi_{5ij}] = \beta_{0j(1)}+ \beta_{1j(1)}*(\text{Age}_{ij})+\beta_{2j(1)}*(\text{Sex}_{ij})+\beta_{3j(1)}*(\text{Education}_{ij})+\beta_{4j(1)}*(\text{Material Deprivation}_{ij})+ \beta_{5j(1)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{2ij}/\phi_{5ij}] = \beta_{0j(2)}+ \beta_{1j(2)}*(\text{Age}_{ij})+\beta_{2j(2)}*(\text{Sex}_{ij})+\beta_{3j(2)}*(\text{Education}_{ij})+\beta_{4j(2)}*(\text{Material Deprivation}_{ij})+ \beta_{5j(2)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{3ij}/\phi_{5ij}] = \beta_{0j(3)}+ \beta_{1j(3)}*(\text{Age}_{ij})+\beta_{2j(3)}*(\text{Sex}_{ij})+\beta_{3j(3)}*(\text{Education}_{ij})+\beta_{4j(3)}*(\text{Material Deprivation}_{ij})+ \beta_{5j(3)}*\text{Residential Environment Exposure}_{ij}$
$\log[\phi_{4ij}/\phi_{5ij}] = \beta_{0j(4)}+ \beta_{1j(4)}*(\text{Age}_{ij})+\beta_{2j(4)}*(\text{Sex}_{ij})+\beta_{3j(4)}*(\text{Education}_{ij})+\beta_{4j(4)}*(\text{Material Deprivation}_{ij})+ \beta_{5j(4)}*\text{Residential Environment Exposure}_{ij}$

Level-2 Model

$\beta_{0(1)} = \gamma_{00(1)}+u_{0j(1)}$
$\beta_{1(1)} = \gamma_{10(1)}$
$\beta_{2(1)} = \gamma_{20(1)}$

$\beta_{3(1)} = \gamma_{30(1)}$
$\beta_{4(1)} = \gamma_{40(1)}$
$\beta_{5(1)} = \gamma_{50(1)}$

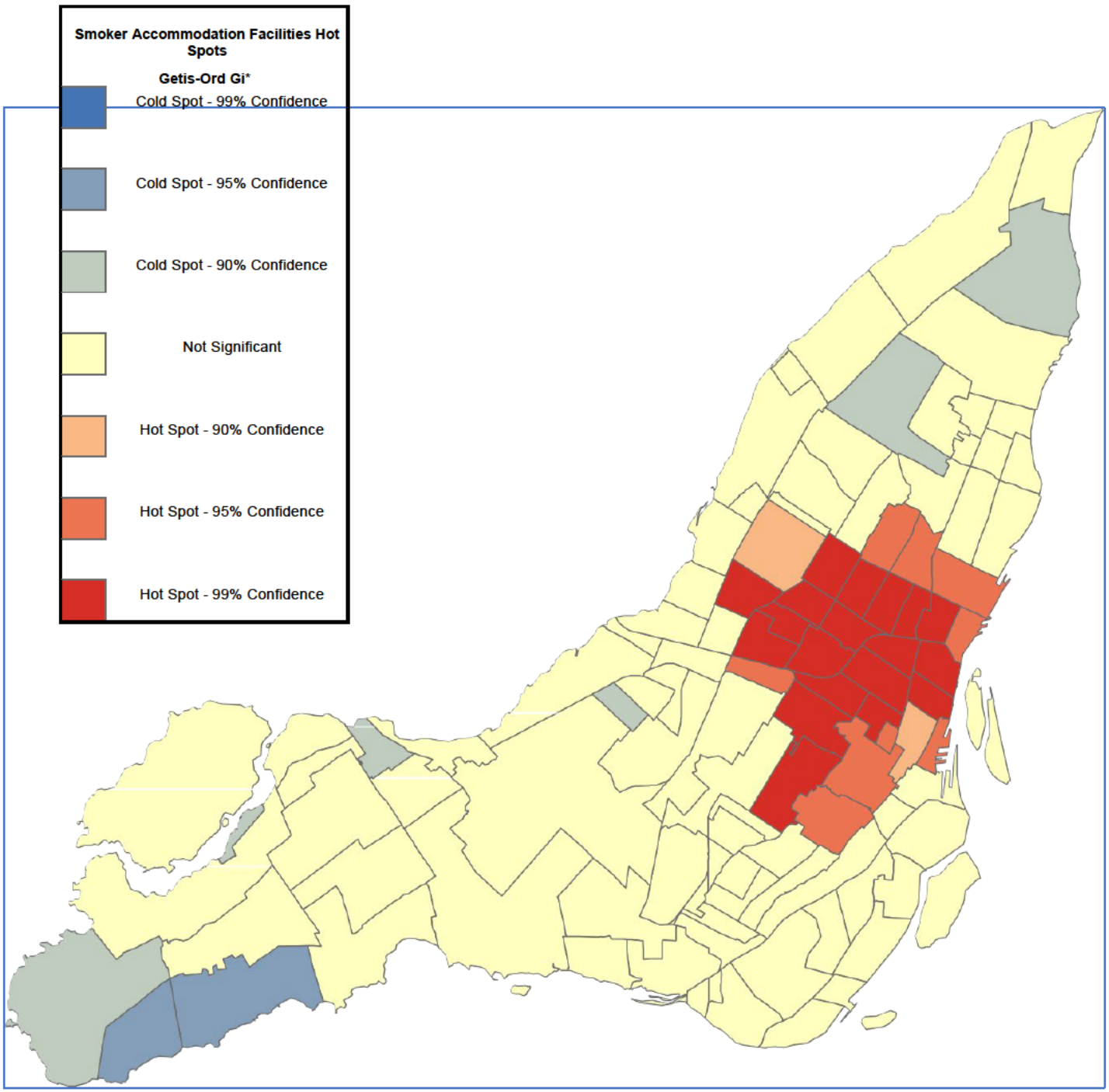
$\beta_{0(2)} = \gamma_{00(2)}$
$\beta_{1(2)} = \gamma_{10(2)}$
$\beta_{2(2)} = \gamma_{20(2)}$
$\beta_{3(2)} = \gamma_{30(2)}$
$\beta_{4(2)} = \gamma_{40(2)}$
$\beta_{5(2)} = \gamma_{50(2)}$

$\beta_{0(3)} = \gamma_{00(3)}$
$\beta_{1(3)} = \gamma_{10(3)}$
$\beta_{2(3)} = \gamma_{20(3)}$
$\beta_{3(3)} = \gamma_{30(3)}$
$\beta_{4(3)} = \gamma_{40(3)}$
$\beta_{5(3)} = \gamma_{50(3)}$

$\beta_{0(4)} = \gamma_{00(4)}$
$\beta_{1(4)} = \gamma_{10(4)}$
$\beta_{2(4)} = \gamma_{20(4)}$
$\beta_{3(4)} = \gamma_{30(4)}$
$\beta_{4(4)} = \gamma_{40(4)}$
$\beta_{5(4)} = \gamma_{50(4)}$

APPENDIX VIII: Getis-Ord GI* Hot Spot Analysis of Smoker Accommodation Facilities by Sociological Neighbourhood

Getis-Ord GI* Hot Spot Analysis of Smoker Accommodation Facilities by Sociological Neighbourhood



APPENDIX IX: Ghenadenik et al. (2018). Preventive Medicine 111: 35-40

Title: Neighbourhoods and obesity: a prospective study of characteristics of the built environment and their association with adiposity outcomes in children in Montreal, Canada

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ABSTRACT

This paper examined prospective associations between built environment features assessed at baseline using direct audits and adiposity outcomes two years later in Montreal, Canada. Data stem from the Quebec Adipose and Lifestyle Investigation in Youth study of 630 children aged 8-10 years with a parental history of obesity. Baseline measurements took place between 2005 and 2008. Follow-up took place between 2008 and 2011. Built environment features were assessed at baseline in up to 10 contiguous street segments around participants' residential addresses using on-site audits. Analyses were restricted to participants who reported the same address both at baseline and follow-up. Prospective associations between adiposity outcomes at follow-up (BMI z-score and waist-height ratio) and built environment features at baseline (traffic-calming features, pedestrian aids, disorder, physical activity facilities, convenience stores, and fast-food restaurants) were examined using multivariable regression models. 391 children were included in the analyses. In fully-adjusted models, children living in residential areas with presence of pedestrian aids had lower BMI z-score, and lower waist-height ratio. Also, children residing in residential areas with at least one convenience store had lower BMI z-score, and lower waist-height ratio at follow-up. Findings provide evidence of the potential role of street-level urban design features in shaping childhood adiposity. To better inform policy and intervention, future research should explore the possibility of reducing obesogenic neighbourhoods by enhancing street-level design features.

Keywords: childhood obesity, adiposity, built environment, neighbourhoods, prospective

INTRODUCTION

The prevalence of childhood overweight and obesity has increased dramatically over the past four decades (1). Although overweight trends have improved and obesity appears to have plateaued in recent years, over 1 in 4 Canadian children aged 6 to 19 years remain overweight or obese (2). Obesity has a range of associated health complications, chiefly cardiovascular disease (3, 4) which we know now to have its origins in childhood (5). Moreover, obese children may be up to five times more likely to become obese adults, compared to their leaner counterparts (6).

The etiology of obesity is complex, influenced by numerous behavioural, psychosocial, genetic and environmental determinants (7). Among the latter, several reviews have implicated features of the built environment. These features are thought to influence weight-related outcomes via physical activity, outdoor play, active transportation, dietary habits, sedentary behaviour, and other energy-related putative mediators or precursors to obesity (8-13). Built environment features previously investigated for their potential to influence weight-related outcomes in children and adolescents include proximity to recreational and physical activity (PA) facilities (8, 10, 12-15), proximity and/or density of fast food restaurants (12, 14, 15), traffic density (16-18), road safety (16-18), land-use mix (19-21), street connectivity (19, 20), walkability (21), residential density (19, 20), crime-related and other neighbourhood safety measures (14, 22-24), and disorder/incivilities (25-27).

Still, the potential role of most of these features in shaping weight-related outcomes in children is not consistently supported in the literature .(8-10). This is due in part to substantial heterogeneity in conceptual and methodological approaches across studies (8, 9, 11). A variety of factors are at the base of these differences, including how built environment features are measured, defined and operationalized (8, 9, 11), and a tendency to rely on cross-sectional designs (8-10, 13). These issues limit our ability to make causal inferences, and to better understand the mechanisms needed to inform policy (28). Moreover, only a few studies have used direct assessments or audits to measure some features of residential built environments and none, at least to our knowledge, have included a comprehensive set of indicators potentially associated with adiposity outcomes in children. Direct assessments can have several advantages

over administrative databases or other secondary data. Notably, while resource-intensive, direct assessments allow for a standardized approach to assess built environment features, they can provide up-to-date data collection, capture nuances in a finer level of detail than administrative databases, and they can be tailored to measure specific geographic scales (e.g.: different buffer zone types vs. fixed administrative spatial units) at which health-related processes are thought to operate.

The objective of this study is to examine prospective associations between distinct built environment street-level features assessed at baseline using direct observation and adiposity outcomes two years later in Montreal, Canada. Our hypotheses are that 1) children residing in neighbourhoods with features that facilitate physical activity and active transportation (e.g.: traffic calming features, pedestrian aids, physical activity facilities) will have lower BMI z-scores and waist-height ratios at follow-up, whereas 2) those residing in neighbourhoods with potentially obesogenic features (e.g.: presence of disorder, fast food restaurants and convenience stores) will have higher BMI z-scores and waist-height ratios at follow-up.

METHODS

Study Sample

This study was conducted within the context of the ongoing QUALITY cohort (Quebec Adipose and Lifestyle Investigation in Youth), a longitudinal investigation of the natural history of obesity and cardiovascular risk in Quebec in high-risk youth. A school-based recruitment strategy was used to identify potential participants. To this end, flyers were distributed to parents of children in grades 2-5 attending 1040 elementary Quebec schools located within 75 kilometres of Montreal, Quebec City and Sherbrooke. Of the 3350 families expressing interest in participating, 1320 met the inclusion criteria: 1) having a Caucasian child of Western European ancestry aged 8 to 10 years; 2) having at least one obese biological parent , since parental obesity is recognized in the literature as an important risk factor for childhood obesity (29-31); and 3) both biological parents being available and agreeing to participate. A total of 630 participants (48% of eligible families) completed a baseline visit between 2005 and 2008. Biological and physiological measurements were taken by trained nurses at the Unité de recherche clinique du Centre Hospitalier Universitaire Sainte-Justine in Montreal and Hôpital

Laval in Quebec City. During this visit, an interviewer-administered questionnaire for children and self-administered questionnaires for parents were also completed. Questionnaires included items related to lifestyle behaviours and health outcomes for children and parents. Self-administered questionnaires also included socio-demographic, and children/other family members' medical history. Follow-up questionnaires, and biological and physiological measurements were completed two years later, when children were aged 10-12 years. Written informed consent was obtained from the parents, and assent was provided by the children. Detailed information regarding the QUALITY study design and methods is available elsewhere (32).

The analyses described in this paper are restricted to participants residing in the Montreal Metropolitan Area (built environment features were not measured elsewhere), for which 1) complete baseline data were available (n=506), 2) complete follow-up measurements were available (n=458), and 3) who resided at the same address both at baseline and follow-up (n=391), to reduce risk of misclassification. Approximately one third of responders resided on the Island of Montreal, in more densely populated neighbourhoods, while two thirds lived in the surrounding predominantly suburban areas.

Measurement of Built Environment Features

Participants' residential neighbourhoods were assessed at baseline using the QUALITY Neighbourhood on-site audit tool, an observation grid adapted from an existing neighbourhood assessment instrument.(33) This grid includes a checklist scoring 60 street-level built environment features surrounding each participant's residential address. Audits were conducted by independent pairs of trained observers. Inter-rater reliability was substantial (kappa >0.60) (34) for most of the indicators used in our analyses for which this information was available (26). For details see Supplementary Table 1. Up to ten street segments around each participant's residential address, including the street segment on which the family was located, and up to nine first and second-degree connecting streets were audited. This area represents a road network buffer ranging from 200-400 metres approximately from the family residence. In cases of discordance between assessments, consensus was sought through additional audits and discussion (35).

Six street-segment level categories of features comprising 19 items were retained for this analysis; (exclusions were largely due to redundant items and those with little or no variation): 1) presence of traffic calming features (i.e.: speed bumps, mid-street section stop signs, 30km/h speed limit signs, traffic obstacles, and traffic lights), 2) presence of pedestrian aids (i.e.: zebra crossings, mid-street section crossings, other marked pedestrian crossings, pedestrian lights, 4-way stop signs, and wider sidewalks), 3) presence of physical disorder (i.e.: presence of graffiti, signs of vandalism, presence of litter, and presence of abandoned buildings), 4) presence of PA facilities (i.e.: sports centres, and playgrounds/outdoor PA facilities), 5) presence of fast-food restaurants, and 6) presence of convenience stores.

Given that the prevalence of any given item was generally low, the four indices grouping multiple features were operationalized as dichotomous indicators for the presence of at least one feature in any of the street segments surrounding participants' residences (0= no presence, 1=presence). Details are available in Supplementary Table 1.

Outcome measures

Child weight and height were measured at baseline, and again at follow-up two years later. Measurements were performed by a trained nurse according to standardized protocols, using an electronic scale for weight and a stadiometer for height (32). Two adiposity measures were used in this paper: 1) Center for Disease Control age- and sex-adjusted BMI z-score (36), a valid indicator of adiposity in children (37) and well-established correlate of different adiposity-related pediatric cardiometabolic risk factors, and 2) waist-height ratio (both measured in cm), a measure that is increasingly advocated as a relevant indicator of central adiposity, potentially superior to BMI alone in detecting cardiometabolic risk, even in children who are not overweight or obese (38, 39).

Potential confounders

Child sex, maternal BMI, paternal BMI, parental education, area-level deprivation, and residential density (all measured at baseline), and child age at follow-up, well-known potential confounders, were included in regression models. There was no multicollinearity between variables, except for maternal BMI and paternal BMI, which were very weakly (r=0.16), albeit

significantly correlated. Puberty was measured using the 5-category Tanner scale, which describes pubertal development (40, 41), but was not included in statistical models.

Age, maternal BMI and paternal BMI were modeled as continuous variables. Parental education was modeled as a dichotomous variable: children having at least one parent with a university degree were coded '1'. Area-level material deprivation was operationalized using a validated index based on census data and measured as a continuous variable, centered around the mean score for the Montreal Metropolitan Area (42). This index combines the proportion of persons who have no high-school diploma, the ratio of employment to population and average income. Material deprivation was computed at the dissemination area level (the smallest geographic area for which census data are available in Canada, with a population of 400 to 700 persons) (43) and linked to the residential addresses of participants. Residential density was operationalized as the number of households per hectare within residence-centered 1km buffers.

Statistical Analyses

Following descriptive analyses, we first considered whether our data was of a hierarchical nature. Since participants were widely distributed within the Montreal Metropolitan Area, the use of multilevel models was deemed inappropriate. As our objective was to examine the potential influences on adiposity resulting from a prolonged exposure to specific types of neighbourhoods rather than changes in adiposity outcomes, associations were examined using linear regression models without baseline adiposity adjustment. This strategy was chosen to mitigate the potential for spurious associations, notably among more obese children for which what may appear to be a decrease in adiposity is actually driven by a sudden increase in height due to possible variations in growth spurts and onset of puberty.

Unadjusted models predicting BMI z-score and waist-height ratio at follow-up using each of the six built environment variables as predictors were first tested. Then, a series of fully-adjusted models were tested including built environment features significantly associated with adiposity outcomes in unadjusted models as predictors, as well as the above-described variables. As there was no evidence of multicollinearity (VIFs were between 1.03-1.20), fully-adjusted models including all six built environment features and all potential confounders were also tested. Given

the relatively low number of missing data (n=11), participants with missing data on any of these variables of interest were excluded in fully-adjusted models. All analyses were performed using IBM SPSS Statistics v24 software.

RESULTS

A slightly higher proportion of participants in the analytic sample were boys (54.7%). The mean age at follow-up was 11.7 years. Most children (80.6%) had not initiated puberty at baseline, whereas at follow-up more than half (61.4%) had. Slightly more than half (53.7%) had at least one parent with a university degree at baseline, above the mean educational attainment (29.6% of adults in 2011) in the Montreal Census Area (44). The mean BMI z-score at follow-up for children was 0.69 (SD=1.05), whereas their mean waist-height ratio at follow-up was 0.48 (SD=0.08). Mean baseline maternal BMI was 29.9 kg/m2, whereas mean baseline paternal BMI was 30.5 kg/m2.

Table 1. Descriptive information for 391 QUALITY participants at baseline and follow-up (Montreal, 2005-2011)

Variable	Baseline	Follow-Up
Mean age in years, (SD)	9.61 (0.88)	11.66 (0.89)
Sex		
Boys, (%)	214 (54.7)	214 (54.7)
Girls, (%)	177 (45.3)	177 (45.3)
Pubertal status		
Puberty not initiated, (%)	315 (80.6)	113 (28.9)
Puberty initiated, (%)	74 (18.9)	240 (61.4)
Missing data	2 (0.5)	38 (9.7)
Mean child BMI z-score, (SD)	0.67 (1.06)	0.69 (1.05)
Mean child waist-height ratio, (SD)	0.48 (0.07)	0.48 (0.08)
Mean maternal BMI at baseline, (SD)	29.9 (6.61)	-
Missing data	1	-
Mean paternal BMI at baseline, (SD)	30.5 (5.55)	-
Missing data	7	-
Parental education at baseline		
At least 1 parent with university degree, (%)	210 (53.7)	-
No parent with university degree, (%)	180 (46.0)	-
Missing data	1 (0.3)	-

At least one traffic calming feature was present in 68.8% of street sections surrounding residential addresses. Most neighbourhoods (92.8%) had at least one pedestrian aid: 45.5% had one or more pedestrian aid types present, whereas 47.3% had two or more. Indicators of physical disorder were present in 34.8% of neighbourhoods. Nearly one-quarter (22.3%) of participating households had at least one convenience store in the surrounding area, and 11.3% had at least one fast food restaurant present. Half of the participants' neighbourhoods (50.1%) included at least one PA facility. Items were weakly or very weakly correlated with each other, except for convenience stores and fast food restaurants (r=0.45), and convenience stores and indicators of disorder (r=0.35), which were moderately correlated.

The mean material deprivation index was slightly below zero, indicating the sample's relatively lower material deprivation level compared to the mean in the Montreal Metropolitan Area. The mean residential density per hectare was 12.85, (range= 0.02- 71.96), illustrative of a range of low-density suburban to high-density core downtown residential areas.

Table 2. Built environment features and area-level potential confounders for 391 areas surrounding residential addresses of participants at baseline

Variable	N=391
Presence of at least 1 traffic calming feature, (%)	269 (68.8)
Presence of at least 1 pedestrian facilitating feature (%)	363 (92.8)
No presence of pedestrian aids	*28 (7.2)*
Presence of 1 type of pedestrian aids	*178 (45.5)*
Presence of 2 or more types of pedestrian aids	*185 (47.3)*
Presence of at least 1 indicator of disorder, (%)	136 (34.8)
Presence of at least 1 fast food restaurant, (%)	44 (11.3)
Presence of at least 1 convenience store, (%)	87 (22.3)
Presence of at least 1 PA facility, (%)	196 (50.1)
Mean residential density per ha, (SD)	12.85 (14.03)
Mean material deprivation index, (SD)	-0.015 (1.015)

Table 3 shows results from unadjusted linear regression models predicting adiposity outcomes at follow-up, with built environment features measured at baseline as independent variables. Living in residential areas with presence of pedestrian aids was associated with a lower BMI z-score at follow-up (β=-0.625, 95% CI: -0.829, -0.421), and with a lower waist-height ratio at follow-up (β=-0.049, 95% CI: -0.064, -0.034). Also, participants residing in areas with the presence of at least one convenience store had a lower BMI z-score at follow-up (β=-0.262, 95% CI: -0.389, -0.135), and a lower waist-height ratio at follow-up (β=-0.018, 95% CI: -0.027, -0.009). No other statistically significant associations were observed between any of the features and outcomes of interest.

Table 3. Results from 6 unadjusted linear regression models predicting adiposity at follow-up among 391 children residing in Montreal, Canada using built environment features as predictors

	Outcome	
	BMI z-Score	**WtHR**
Built environment features	**β (SE)**	**β (SE)**
Presence of at least 1 traffic calming feature	-0.086 (0.115)	-0.009 (0.008)
Presence of at least 1 pedestrian facilitating feature	-0.625 (0.204)**	-0.049 (0.015)**
Presence of at least 1 disorder indicator	-0.021 (0.112)	-0.002 (0.008)
Presence of at least 1 fast food restaurant	-0.037 (0.168)	-0.002 (0.012)
Presence of at least 1 convenience store	-0.262 (0.127)*	-0.018 (0.009)*
Presence of at least 1 physical activity resource	-0.024 (0.106)	-0.002 (0.008)

Abbreviation: BMI, body mass index; WtHR, waist-to-height ratio. *P<0.05; **P<0.01.

Table 4 shows results from fully-adjusted models. Models 1 and 2 predicted adiposity outcomes at follow-up using presence of at least one pedestrian facilitating feature as predictor. Models 3 and 4 used the same approach, but with presence of at least one convenience store as predictor. Models 5 and 6 predicted the outcomes of interest using all six built environment features as predictors.

After adjusting for potential confounders, children living in areas with pedestrian aids had lower BMI z-score (Model 1; β=-0.674, 95% CI: -0.878, -0.470), and lower waist-height ratio (Model 2; β=-0.052, 95% CI: -0.067, -0.037). Also, children living in areas with at least one convenience store had lower BMI z-score (Model 3; β=-0.282, 95% CI: -0.409, -0.155), and lower waist-height ratio (Model 4; β=-0.019, 95% CI: -0.028, -0.010). No associations were

found following adjustment for potential confounders in models using the other four built environment features as independent predictors (results not shown).

Also, in fully-adjusted models assessing all six built environment features simultaneously in the same model, presence of pedestrian aids and presence of convenience stores remained significantly associated with BMI z-score (Model 5; β=-0.651, 95% CI: -0.859, -0.443 for pedestrian aids; β=-0.303, 95% CI: -0.451, -0.155 for convenience stores), and presence of pedestrian aids remained significantly associated with waist-height ratio (Model 6; β=-0.051, 95% CI: -0.066, -0.036).

Table 4. Results of fully-adjusted linear regression models predicting adiposity outcomes at follow-up among 382 children from the QUALITY cohort, Montreal, 2005-2011

	Outcome					
	Model 1 BMI z-Score†	Model 2 WtHR†	Model 3 BMI z-Score††	Model 4 WtHR††	Model 5 BMI z-Score†††	Model 6 WtHR†††
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Built environment features						
Presence of at least 1 pedestrian facilitating feature	-0.674 (0.204)**	-0.052 (0.015)**	-	-	-0.651 (0.208)**	-0.051 (0.015)**
Presence of at least 1 convenience store	-	-	-0.282 (0.127)*	-0.019 (0.009)*	-0.303 (0.148)*	-0.019 (0.011)
Presence of at least 1 traffic calming feature	-	-	-	-	0.018 (0.125)	-0.001 (0.009)
Presence of at least 1 disorder indicator	-	-	-	-	0.021 (0.122)	0.002 (0.009)
Presence of at least 1 fast food restaurant	-	-	-	-	0.105 (0.185)	0.007 (0.013)
Presence of at least 1 physical activity resource	-	-	-	-	0.049 (0.111)	0.005 (0.008)
Individual, parental, and neighbourhood-level characteristics						
Age at follow-up	0.043 (0.059)	0.003 (0.004)	0.061 (0.060)	0.004 (0.004)	0.047 (0.060)	0.003 (0.004)
Sex (ref boy)	0.043 (0.106)	-0.002 (0.008)	0.061 (0.107)	-0.001 (0.008)	0.040 (0.108)	-0.002 (0.008)
Maternal BMI score at baseline	0.017 (0.008)*	0.001 (0.001)	0.017 (0.008)*	0.001 (0.001)	0.018 (0.008)*	0.001 (0.001)
Paternal BMI score baseline	-0.000 (0.010)	0.000 (0.001)	0.001 (0.010)	0.000 (0.001)	0.000 (0.010)	0.000 (0.001)
Parental education at baseline (ref no parent with university degree)	-0.178 (0.107)	-0.014 (0.008)	-0.155 (0.107)	-0.012 (0.008)	-0.176 (0.107)	-0.014 (0.008)
Residential density per ha	0.002 (0.004)	0.000 (0.000)	0.002 (0.004)	0.000 (0.000)	0.002 (0.004)	0.000 (0.000)
Material deprivation	0.042 (0.053)	0.000 (0.004)	0.031 (0.053)	-0.001 (0.004)	0.042 (0.053)	0.000 (0.004)

Abbreviation BMI, body mass index; WtHR, waist-to-height ratio. *P<0.05; **P<0.01.

† Models 1 and 2 multivariate linear regression predicting adiposity outcomes at follow-up using presence of at least 1 pedestrian facilitating feature as predictor, adjusted for potential confounders

†† Models 3 and 4 multivariate linear regression predicting adiposity outcomes at follow-up using presence of at least 1 convenience store as predictor, adjusted for potential confounders

††† Models 5 and 6 multivariate linear regression predicting adiposity outcomes at follow-up using all built environment features as predictors, adjusted for potential confounders

Note Although our focus was not on change in adiposity over the two- year period, models in which we include baseline BMI z-score and WtHR yielded a coefficient for pedestrian aids of (β=-0.377, 95% CI -0.541, -0.213, p=0.022) and (β=-0.027, 95% CI -0.039, -0.015, p=0.027) respectively

DISCUSSION

We found that the presence of pedestrian aids within residential neighbourhood environments was associated with a lower BMI z-score and a lower waist-height ratio in children after a 2-year follow up. Additional analyses with an alternative operationalization of this variable (i.e.: presence of 0, 1, or 2 or more pedestrian aid types) showed no dose-response effects, suggesting that having any pedestrian aid type in residential neighbourhoods may have a beneficial influence on child adiposity. Furthermore, when stratifying analyses using a median split for residential density per square kilometre, the effect of pedestrian aids on adiposity outcomes was more pronounced in higher density zones, suggesting that it is in higher density areas that pedestrian aids may matter the most (data not shown).

These findings provide evidence suggesting that street-level infrastructure designed to promote walking, such as pedestrian crossing lights and wider sidewalks, have potential to contribute to lower subsequent adiposity in children, possibly via greater energy expenditure. Several reviews have indeed highlighted pedestrian safety structures as one of the features most consistently associated with PA in children (8, 45, 46). Their presence may not only promote walking, but also cycling, outdoor play, and other types of PA. For example, a cross-sectional Dutch study of built environment correlates of walking and cycling in urban children aged 6 to 11 years found that the presence of pedestrian crossings was positively associated with walking and cycling to school, as well as with cycling for transportation (17). Similarly, presence of pedestrian aids was associated with walking to school in children residing in Toronto, Canada (47), and in children residing in various locations across Texas (48).

Even though pertaining to a somewhat similar domain, traffic calming features were not associated with adiposity outcomes in children aged 10 to 12 years. Similar results were reported in the above-referenced Dutch study of correlates, which found that the presence of traffic lights was not associated with cycling and negatively associated with walking for transportation (17). A potential explanation for differences between findings for pedestrian aids and those for traffic calming features may be that the latter can be indicative of a more traffic-dense setting (requiring additional safety due to greater danger), which in turn may not be conducive to spending time outdoors in children of this age group. A cross-sectional study of environmental correlates of outdoor play provides evidence supporting this hypothesis. Specifically, findings showed a positive association between presence of pedestrian crossings without traffic lights and outdoor play in children aged 7-9 years, whereas a negative association was found in presence of pedestrian crossings with traffic lights (49).

Like other studies (50-52), no associations between presence of fast food restaurants and adiposity outcomes were observed. Conversely, and contrary to our expectations, presence of convenience stores was associated with lower BMI z-scores but not with waist-height ratio following adjustment for potential confounders. An explanation for these findings may be the use of a "crude" classification that categorizes fast food restaurants and convenience stores as unhealthy food sources as opposed to healthy food sources. In-store assessments of the food

environment may have revealed a diversity in quality and pricing of foods offered within these stores (52). A recent cross-sectional study of neighbourhood food environments and overweight/obesity in children in a Canadian urban agglomeration (53) provides evidence of this. Findings from this study show that children with access to higher quality and lower price food items, regardless of the type of food outlet within an 800m buffer zone centered on their residential addresses, had lower odds of overweight/obesity.

Signs of physical disorder and incivilities have been hypothesized as potential barriers to healthy weight-related behaviours in children (54, 55). Nonetheless, evidence regarding the role of this feature in shaping weight-related outcomes is inconsistent. For instance, whereas one review reported some supporting evidence linking this feature to PA in children (8), others found no associations with this outcome (10, 12), and no associations with BMI (12). In line with the latter reviews, no associations between this feature and adiposity outcomes were observed in our study. Differences in findings may be dependent on whether disorder and incivilities are indeed perceived as indicators of safety hazards. Supporting this hypothesis, a nationally representative study in the United States (albeit in children ages 5-6 years) found that associations between PA and neighbourhood quality, including disorder/incivilities were fully mediated by parental perceptions of safety (56).

We found no associations between presence of PA facilities and adiposity outcomes. This is in line with a review of environmental correlates of childhood obesity, which reported no evidence of links with proximity and accessibility to PA facilities, playgrounds, parks and other outdoor resources (9). Similarly, a review of neighbourhood environments and PA in children found inconsistent evidence regarding associations between parks and recreation facilities and objectively-measured PA (8). A factor that may partly explain the absence of associations is the use of measures of PA facilities that are unable to capture the nuances and specific characteristics of these resources (e.g.: quality of facilities, specific features provided). For example, while an area may have a high presence of parks and playgrounds, if these are poorly maintained or have features unattractive to children, they may be less likely to be associated with PA. In this regard, another analysis based on the QUALITY cohort looking specifically at

park types found that living near esthetically-pleasing parks with few team sports installations was associated with lower truncal fat percentage, and more favourable PA outcomes (57).

Strengths of this study include its prospective design, the use of a validated neighbourhood assessment tool, and the reduction of potential misclassification by restricting our sample to children residing at the same address for the duration of the follow up. Certain limitations nonetheless should be acknowledged. Given that participants were relatively more affluent than average Quebec families this may limit the generalizability of findings. Furthermore, selection bias may have occurred due to loss to follow-up of participants living in more disadvantaged areas, who tend to have worse adiposity outcomes. Still, given the low attrition rate, this risk is likely low.

CONCLUSIONS

This study contributes to the literature on neighbourhoods and adiposity in children. Findings provide evidence of the potential role of pedestrian aids in shaping childhood adiposity outcomes. To better inform policy and intervention, future research should also other built environment features, including how children and parents perceive them regarding their ability to promote or deter weight-related behaviours. Also, findings showing an unexpected inverse association between convenience stores and adiposity outcomes, suggest that the use of more nuanced measures of built environment features (e.g.: type of foods sold in fast food restaurants and convenience stores, quality of PA resources) may contribute to a better understanding of their potential role in shaping child weight-related outcomes. Finally, studies documenting changes in these features over time, and how they may relate to weight-related behaviours and adiposity are likely to help elucidate mechanisms underlying associations between built environments and weight-related outcomes in children.

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BIBLIOGRAPHY

1. Roberts KC, Shields M, de Groh M, Aziz A, Gilbert J. Overweight and obesity in children and adolescents: Results from the 2009 to 2011 Canadian Health Measures Survey. Health Reports. 2012;23(3).

2. Rodd C, Sharma AK. Recent trends in the prevalence of overweight and obesity among Canadian children. CMAJ. 2016;188(13):E313-E20.

3. Reilly JJ, Methven E, McDowell ZC, Hacking B, Alexander D, Stewart L, et al. Health consequences of obesity. Arch Dis Child. 2003(88):748-52.

4. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obes Rev. 2008;9(5):474-88.

5. Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. Health Promotion and Chronic Disease Prevention in Canada. 2016;36(9):194-8.

6. Simmonds M, Llewellyn A, Owen CG, Woolacott N. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. Obes Rev. 2016;17(2):95-107.

7. Spruijt-Metz D. Etiology, Treatment and Prevention of Obesity in Childhood and Adolescence: A Decade in Review. J Res Adolesc. 2011;21(1):129-52.

8. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth a review. Am J Prev Med. 2011;41(4):442-55.

9. Dunton GF, Kaplan J, Wolch J, Jerrett M, Reynolds KD. Physical environmental correlates of childhood obesity: a systematic review. Obes Rev. 2009;10(4):393-402.

10 . de Vet E, de Ridder DT, de Wit JB. Environmental correlates of physical activity and dietary behaviours among young people: a systematic review of reviews. Obes Rev. 2011;12(5):e130-42.

11. Feng J, Glass TA, Curriero FC, Stewart WF, Schwartz BS. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place. 2010;16(2):175-90.

12. Galvez MP, Pearl M, Yen IH. Childhood obesity and the built environment. Curr Opin Pediatr. 2010;22(2):202-7.

13. Safron M, Cislak A, Gaspar T, Luszczynska A. Micro-environmental characteristics related to body weight, diet, and physical activity of children and adolescents: a systematic umbrella review. Int J Environ Health Res. 2011;21(5):317-30.

14. Carroll-Scott A, Gilstad-Hayden K, Rosenthal L, Peters SM, McCaslin C, Joyce R, et al. Disentangling neighborhood contextual associations with child body mass index, diet, and physical activity: the role of built, socioeconomic, and social environments. Soc Sci Med. 2013;95:106-14.

15. Wasserman JA, Suminski R, Xi J, Mayfield C, Glaros A, Magie R. A multi-level analysis showing associations between school neighborhood and child body mass index. Int J Obes. 2014;38(7):912-8.

16. Carver A, Timperio AF, Crawford DA. Neighborhood road environments and physical activity among youth: the CLAN study. J Urban Health. 2008;85(4):532-44.

17. de Vries SI, Hopman-Rock M, Bakker I, Hirasing RA, van Mechelen W. Built environmental correlates of walking and cycling in Dutch urban children: results from the SPACE study. Int J Environ Res Public Health. 2010;7(5):2309-24.

18. Timperio A, Salmon J, Telford A, Crawford D. Perceptions of local neighbourhood environments and their relationship to childhood overweight and obesity. Int J Obes. 2005;29(2):170-5.

19. Frank L, Kerr J, Chapman J, Sallis J. Urban Form Relationships With Walk Trip Frequency and Distance Among Youth. Am J Health Promot. 2007;21(S4):305-11.

20. Larsen K, Gilliland J, Hess P, Tucker P, Irwin J, He M. The Influence of the Physical Environment and Sociodemographic Characteristics on Children's Mode of Travel to and From School. Am J Public Health. 2009;99(3):520-6.

21. Spence JC, Cutumisu N, Edwards J, Evans J. Influence of neighbourhood design and access to facilities on overweight among preschool children. Int J Pediatr Obes. 2008;3(2):109-16.

22. Côté-Lussier C, Mathieu ME, Barnett TA. Independent associations between child and parent perceived neighborhood safety, child screen time, physical activity and BMI: a structural equation modeling approach. Int J Obes. 2015;39(10):1475-81.

23. Sandy R, Tchernis R, Wilson J, Liu G, Zhou X. Effects of the built environment on childhood obesity: the case of urban recreational trails and crime. Econ Hum Biol. 2013;11(1):18-29.

24. Davison KK. School Performance, Lack of Facilities, and Safety Concerns: Barriers to Parents' Support of Their Children's Physical Activity. Am J Health Promot. 2009;23(5):315-9.

25. Kimbro RT, Brooks-Gunn J, McLanahan S. Young children in urban areas: links among neighborhood characteristics, weight status, outdoor play, and television watching. Soc Sci Med. 2011;72(5):668-76.

26. Van Hulst A, Gauvin L, Kestens Y, Barnett TA. Neighborhood built and social environment characteristics: a multilevel analysis of associations with obesity among children and their parents. Int J Obes. 2013;37(10):1328-35.

27. de Vries SI, Bakker I, van Mechelen W, Hopman-Rock M. Determinants of Activity-friendly Neighborhoods for Children: Results From the SPACE Study. Am J Health Promot. 2007;21(S4):312-6.

28. Sallis J, Glanz K. The Role of Built Environments in Physical Activity, Eating, and Obesity in Childhood. Future Child. 2006;16(1):89-108.

29. Anzman SL, Rollins BY, Birch LL. Parental influence on children's early eating environments and obesity risk: implications for prevention. Int J Obes. 2010;34(7):1116-24.

30. Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: a systematic review. Int J Obes. 1999;23(S8):S1-S107.

31. Strauss RS, Knight J. Influence of the Home Environment on the Development of Obesity in Children. Pediatrics. 1999;103(6).

32. Lambert M, Van Hulst A, O'Loughlin J, Tremblay A, Barnett TA, Charron H, et al. Cohort profile: the Quebec adipose and lifestyle investigation in youth cohort. Int J Epidemiol. 2012;41(6):1533-44.

33. Paquet C, Cargo M, Kestens Y, Daniel M. Reliability of an instrument for direct observation of urban neighbourhoods. Landscape Urban Planning. 2010;97(3):194-201.

34. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. Biometrics. 1977;33(1):159-74.

35. Rundle AG, Bader M, Richards CA, Neckerman KM, Teitler JO. Using Google Street View to audit neighborhood environments. Am J Prev Medicine. 2011;40(1):94-100.

36. Centers for Disease Control and Prevention. CDC Growth Charts: United States 2010 [Available from: https://www.cdc.gov/growthcharts/.

37. Kakinami L, Henderson M, Chiolero A, Cole TJ, Paradis G. Identifying the best body mass index metric to assess adiposity change in children. Arch Dis Child. 2014;99(11):1020-4.

38. Mokha JS, Srinivasan SR, DasMahapatra P, Fernandez C, Chen W, Xu J, et al. Utility of waist-to-height ratio in assessing the status of central obesity and related cardiometabolic risk profile among normal weight and overweight/obese children: The Bogalusa Heart Study. BMC Pediatrics. 2010;10(73).

39. Khoury M, Manlhiot C, McCrindle BW. Role of the waist/height ratio in the cardiometabolic risk assessment of children classified by body mass index. J Am Coll Cardiol. 2013;62(8):742-51.

40. Marshall WA, Tanner JM. Variations in Pattern of Pubertal Changes in Girls. Arch Dis Childh. 1969;44:291-303.

41. Marshall WA, Tanner JM. Variations in the Pattern of Pubertal Changes in Boys. Arch Dis Childh. 1970;45:13-23.

42. Pampalon R, Hamel D, Gamache P, Philibert D, Raymond G, Simpson A. An Area-based Material and Social Deprivation Index for Public Health in Québec and Canada. Can J Public Health. 2012;103(S2):S17-S22.

43. Statistics Canada. Census Dictionary: Dissemination Area (DA) 2015 [Available from: https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo021-eng.cfm.

44. Statistics Canada. Census 2011: Education in Canada: Attainment, Field of Study and Location of Study 2015 [Available from: http://census.gc.ca/nhs-enm/2011/as-sa/99-012-x/99-012-x2011001-eng.cfm.

45. Timperio A, Reid J, Veitch J. Playability: Built and Social Environment Features That Promote Physical Activity Within Children. Curr Obes Rep. 2015;4(4):460-76.

46. Larouche R. Built Environment Features that Promote Cycling in School-Aged Children. Curr Obes Rep. 2015;4(4):494-503.

47. Rothman L, To T, Buliung R, Macarthur C, Howard A. Influence of social and built environment features on children walking to school: an observational study. Prev Med. 2014;60:10-5.

48. Oluyomi AO, Lee C, Nehme E, Dowdy D, Ory MG, Hoelscher DM. Parental safety concerns and active school commute: correlates across multiple domains in the home-to-school journey. Int J Behav Nutr Phys Act. 2014;11(32).

49. Aarts MJ, de Vries SI, van Oers H, Schuit AJ. Outdoor play among children in relation to neighborhood characteristics: a cross-sectional neighborhood observation study. Int J Behav Nutr Phys Act. 2012;9(98).

50. Leung CW, Laraia BA, Kelly M, Nickleach D, Adler NE, Kushi LH, et al. The influence of neighborhood food stores on change in young girls' body mass index. Am J Prev Med. 2011;41(1):43-51.

51. Shier V, An R, Sturm R. Is there a robust relationship between neighbourhood food environment and childhood obesity in the USA? Public Health. 2012;126(9):723-30.

52. Griffiths C, Frearson A, Taylor A, Radley D, Cooke C. A cross sectional study investigating the association between exposure to food outlets and childhood obesity in Leeds, UK. Int J Behav Nutr Phys Act. 2014;11(138).

53. Le H, Engler-Stringer R, Muhajarine N. Walkable home neighbourhood food environment and children's overweight and obesity: Proximity, density or price? Can J Public Health. 2016;107(S1):eS42-eS7.

54. Dulin-Keita A, Thind HK, Affuso O, Baskin ML. The associations of perceived neighborhood disorder and physical activity with obesity among African American adolescents. BMC Public Health. 2013;13(440).

55. Franzini L, Elliott MN, Cuccaro P, Schuster M, Gilliland MJ, Grunbaum JA, et al. Influences of Physical and Social Neighborhood Environments on Children’s Physical Activity and Obesity. Am J Public Health. 2007;99(2):271-8.

56. Beets MW, Foley JT. Association of Father Involvement and Neighborhood Quality with Kindergartners' Physical Activity: A Multilevel Structural Equation Model. Am J Health Promotion. 2008;22(3):195-203.

57. Bird M, Datta GD, van Hulst A, Cloutier MS, Henderson M, Barnett TA. A park typology in the QUALITY cohort: Implications for physical activity and truncal fat among youth at risk of obesity. Prev Med. 2016;90:133-8.

Supplementary Table 1. Indicators used to create built environment features for 391 areas surrounding residential addresses of participants at follow-up and inter-rater reliability for selected items of the in-person neighborhood assessment tool used for the QUALITY study

Variable (n=391)		Kappa Coefficient (95% CI)*
Presence of speed bumps, (%)	35 (9.0)	-
Presence of traffic obstacles, (%)	63 (16.1)	-
Presence of traffic lights, (%)	102 (26.1)	-
Presence of mid-section stop signs, (%)	19 (4.9)	0.79 (0.67; 0.90)
Presence of 30 km/h speed limit signs, (%)	203 (51.9)	0.86 (0.83; 0.88)
Presence of zebra crossings, (%)	132 (36.3)	0.83 (0.81; 0.86)
Presence of mid-section pedestrian crossings, (%)	45 (11.5)	0.77 (0.73; 0.81)
Presence of other marked pedestrian crossings, (%)	4 (1.0)	-
Presence of pedestrian lights, (%)	79 (20.2)	-
Presence of 4-way stop signs, (%)	343 (87.7)	0.88 (0.87; 0.89)
Presence of wide sidewalks, (%)	17 (4.3)	-
Presence of graffiti, (%)	99 (25.3)	0.50 (0.45; 0.55)
Presence of signs of vandalism, (%)	14 (3.6)	-
Presence of litter, (%)	63 (16.1)	0.33 (0.26; 0.40)
Presence of abandoned buildings, (%)	12 (3.1)	-
Presence of sports centres, (%)	17 (4.3)	-
Presence of playgrounds/outdoor PA facilities, (%)	193 (49.4)	-

* Note: only a selection of repeated measures were undertaken, for budgetary reasons. Kappa coefficients reported for measures that were repeated

APPENDIX X: Curriculum Vitae

LANGUAGES

English, Spanish (excellent, written and spoken), French (advanced, written and spoken)

EDUCATION

- 2013 – 2019 (expected) Ph.D. in Public Health, Health Promotion option, Université de Montréal, Canada.

  Thesis title : Beyond smoking prevalence: understanding smoking behaviour patterns in young adults and their association with residential environment features.

  Supervisors: Katherine L. Frohlich Ph.D. and Lise Gauvin Ph.D.

- 2012 – 2013 M.Sc. in Community Health, Université de Montréal, Canada (fast-tracked to Ph.D. in Public Health).
- 2011 – 2012 M.Sc. in Health Services Administration, Université de Montréal, Canada.
- 2009 – 2010 Graduate Certificate in Health Care Management, McGill University, Canada.
- 1990 – 1996 B.A. in Business Administration, Universidad de Buenos Aires, Argentina (cum laude).

PUBLICATIONS, PEER-REVIEWED

- Ghenadenik, A.E., Gauvin, L., & Frohlich, K.L. Residential environments and changes in smoking behaviour among young adults: A prospective study using data from the ISIS cohort. *Preventive Medicine*; 123: 48-54. doi: 10.1016/j.ypmed.2019.03.003
- Ghenadenik, A.E., Kakinami, L., Van Hulst, A., Henderson, M., Barnett, T.A. (2018). Neighbourhoods and obesity: a prospective study of characteristics of the built environment and their association with adiposity outcomes in children in Montreal, Canada. *Preventive Medicine*; 111: 35-40. doi:10.1016/j.ypmed.2018.02.018
- Gagné, T., Ghenadenik, A.E. (2018). Rethinking the relationship between socioeconomic status and health: Challenging how socioeconomic status is currently used in health inequality research. *Scandinavian Journal of Public Health*; 46(1): 53-56. doi:10.1177/1403494817744987
- Gagne, T., Ghenadenik, A.E., Shareck, M., Frohlich, K.L. (2016). Expected or completed? Comparing two measures of educational attainment and their influence on the study of social inequalities in health among young adults. *Social Indicators Research*. doi:10.1007/s11205-016-1517-9
- Gagne, T., Ghenadenik, A.E., Abel, T., Frohlich, K.L. (2016) Social inequalities in health information seeking among young adults in Montreal. *Health Promotion International*. doi:10.1093/heapro/daw094

- Ghenadenik, A.E., Frohlich, K.L., Gauvin, L. (2016). Beyond smoking prevalence: exploring the variability of associations between neighbourhood exposures across two nested spatial units and two-year smoking trajectory among young adults. *International Journal of Environmental Research and Public Health*; (13) 106. doi:10.3390/ijerph13010106
- Ghenadenik, A., Rochais, E., Atkinson, S., Bussières, J.F. (2012). Potential risks associated with medication administration, as identified by simple tools and observations. *Canadian Journal of Hospital Pharmacy*; (65) 4: 300-307.

REPORTS

- Ghenadenik, A.E. (2012). A Framework to Develop an Integrated Quality Plan for the McGill University Health Centre. Report developed produced for the for the McGill University Health Centre.

TEACHING

- Teaching Assistant, Promotion de la santé et prévention. École de santé publique, Université de Montréal, Canada. September-December 2018.
- Teaching Assistant, Épidémiologie sociale et promotion/prévention. École de santé publique, Université de Montréal, Canada. January-April 2018.
- Teaching Assistant, Promotion de la santé et prévention. École de santé publique, Université de Montréal, Canada. September-December 2017.
- Teaching Assistant, Promotion de la santé et prévention. École de santé publique, Université de Montréal, Canada. September-December 2015.

PRESENTATIONS

- Ghenadenik, A.E., Gauvin, L., Frohlich, K.L. (2019). Residential environments and smoking behaviour in young adults: A study of 4-year smoking trajectories using data from the ISIS cohort. Poster presented at the 23rd Conference on Health Promotion, Rotorua, New Zealand. April 2019.
- Ghenadenik, A.E., Shareck, M., Vallée, J. (2018). Une approche par l'espace pour comprendre les inégalités sociales de tabagisme. Oral presentation, ISIS Symposium, Montréal, Canada. February 2018.
- Ghenadenik, A.E., Gauvin, L., Frohlich, K.L. (2017).What aspects of living environments influence changes in smoking in young adults? A longitudinal study of environmental exposures. Oral presentation, 17th International Medical Geography Symposium, Angers, France. July 2017
- Ghenadenik, A.E., Kakinami, L., Henderson, M., Barnett, T.A. (2017). Neighbourhoods and obesity: a longitudinal study of characteristics of the built environment and their association with adiposity outcomes in children in Montreal, Canada. Oral presentation, Canadian Public Health Association Conference, Halifax, Canada. June 2017.

- Ghenadenik, A.E., Gauvin, L., Frohlich, K.L. (2017). Variabilité de la prévalence du tabagisme chez les jeunes adultes mesurée à différentes échelles spatiales et examen de l'influence des caractéristiques des milieux résidentiels à l'aide des données du *Interdisciplinary Study of Inequalities in Smoking*. Oral presentation, 85th Congrès de l'ACFAS, Montréal, Canada. May 2017
- Ghenadenik, A.E., Gauvin, L., Frohlich, K.L. (2015). Scale matters: exploring the variability of associations between neighbourhood exposures and smoking across increasingly large spatial units. Oral presentation, 8th European Public Health Conference, Milan, Italy. October 2015
- Ghenadenik, A.E., Frohlich, K.L., Gauvin, L. (2015). Exploring the appropriateness of different spatial units to study neighbourhoods and smoking in young adults: Extent of variability across increasingly large spatial units. Oral presentation, 16th International Medical Geography Symposium, Vancouver, Canada. July 2015

ACADEMIC WORK AND RESEARCH EXPERIENCE

- Research intern, Institut National de Recherche en Santé, Institut Armand-Frappier, Department of Epidemiology, Laval, Canada. September 2016 – April 2017
    - Research project : Exploring Transformations in QUALITY Neighbourhoods Over Time
    - Supervisor: Tracie A. Barnett
    - Designed and conducted analyses of data from the Québec QUALITY cohort.
    - Published a peer-reviewed paper based on the results of these analyses

- Research Assistant, Institute for Administrative Research, University of Buenos Aires, Argentina. March 1993 – July 1994

PUBLIC AND COMMUNITY CONTRIBUTIONS – UNIVERSITY RELATED

- Representative of the Institut de recherche en santé publique de l'Université de Montréal (IRSPUM) at the 2017 Canadian Public Health Association Conference, Halifax, Canada. June 2017

FUNDING

2017

- Canadian Institutes for Health Research Institute Community Support Travel Award ($1,460)

2015

- Fonds de recherche Québec-Santé Doctoral Research Award ($60,000 for 3 years)
- Canadian Institutes for Health Research Institute Community Support Travel Award ($2,398)

- Institut de recherche en santé publique de l'Université de Montréal (IRSPUM) Programme d'aide à la diffusion ($1,309)
- Institut de recherche en santé publique de l'Université de Montréal (IRSPUM) Programme d'aide à la publication ($1,000)

2013

- Faculté des études supérieures et postdoctorales (FESP) de l'Université de Montréal Bourse de recrutement au PhD ($10,000 for 2 years)
- Faculté des études supérieures et postdoctorales (FESP) de l'Université de Montréal Bourse de passage accéléré ($10,000 for 2 years)
- Faculté des études supérieures et postdoctorales (FESP) de l'Université de Montréal Bourse d'excellence pour la maîtrise en sciences ($5,500)

SCIENTIFIC JOURNAL REFEREE

Addiction

Annals of Epidemiology

Canadian Journal of Public Health

Health and Place